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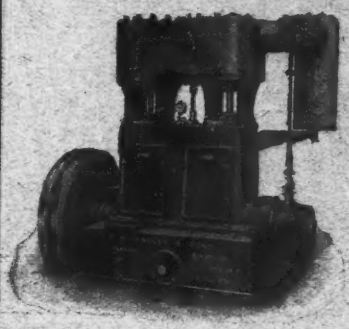

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SCIENCE AND INDUSTRY.

Sir Isaac Newton, shortly before his death, said:—"I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me"—yet Leibnitz estimated that Newton had achieved far more than all other mathematicians put together from the beginning of history. Lord Kelvin, at his jubilee, in reply to the homage of the whole scientific world, said:—"One word characterises the most strenuous of the efforts for the advancement of science that I have made perseveringly during 55 years; that word is *failure*." Yet he towered above all his scientific contemporaries, and was, perhaps, the greatest savant that the world has known. It is, in fact, a trait common to all who have spent their lives in the pursuit of knowledge, and have acquired a profound acquaintance with the hidden mysteries of Nature and Science, that they, more than all others, realise the immensity of the field that lies open before them—shrouded in mists, it is true, and beset with pitfalls, *culs de sac*, false clues, but also holding treasure in store of inconceivable richness for the reward of those who patiently grope amid its gloomy fastnesses. We have as yet but ventured over the border of that illimitable expanse; the further we penetrate into its depths the better we appreciate the wealth that lies beyond, and the greater becomes our strength to overcome the difficulties that confront us. We see, too, how far we have strayed from the true path in the complacent past, when we thought we had approached finality in one or other quest.

These thoughts are prompted by the striking appeal addressed to our American colleagues by Dr. Whitney, in the *Electrical World*, the gist of which we reprint elsewhere in this issue. We have often drawn attention to the splendid work that has been accomplished by the research laboratory of which he is the head, and quite recently Mr. A. P. M. Fleming has reminded the Institution of Electrical Engineers, at Manchester and Newcastle, of the vast resources and assiduous attention which are devoted to industrial research by manufacturing firms in the United States, as well as in Japan and Germany. In cannot be suggested that America has neglected the possibilities of industrial research. Of what, then, does Dr. Whitney accuse a nation which, above all, is noted for utilitarianism and practical common-sense? It is of ignoring the claims of research in pure science, research directed solely to the advancement of human knowledge, without an eye to the commercial results that may accrue. He declares, in effect, that the United States, from the scientific point of view, is a parasitic nation, depending almost wholly upon the labours of the scientists of Europe, who have provided it with the means to cure disease, to communicate by ethereal waves, to radiograph the internal organs of the body, to rid the Isthmus of Panama of the pestilence that made it a death-trap for the engineers of de Lesseps, to transmit power from its waterfalls over hundreds of miles. And, indeed, it is true that, with rare and brilliant exceptions, such as Franklin, Henry, and Langley, the history of the United States can boast of no great pioneers

in pure science as opposed to industries—inventors it has had in plenty, but few discoverers.

Now, there is in this a lesson for ourselves. Engineering in particular, and electrical engineering above all, is built upon science as the foundation. Primary and secondary cells, the dynamo, the arc light, wireless telegraphy, and the X-rays, electro-deposition, the electric furnace, the manufacture of aluminium, alkali, and other products of electrometallurgy and electrochemistry, the fixation of nitrogen, the telegraph, and countless other triumphs of electrical engineering, all derived their origin from the laboratories of men who wooed Science for herself alone, without thought of personal profit—many of the foremost of them, we are proud to recall, of British race. We do not overlook the fact that on the basis of these discoveries, industrial research has given rise to innumerable inventions of the utmost importance to mankind, such as the glow lamp, the telephone, the steam turbine, the polyphase system, the submarine cable, and other commercial developments, in which also our fellow-countrymen have played a leading part. But we live in a time of difficulty and danger, when attention is pre-eminently directed to the commercial possibilities of invention and research, and there is no little risk that in the struggle for commercial supremacy we may lose sight of the higher aims—the general welfare of humanity, and the claims of pure scientific research upon our labours and our purse. Let us, then, lay to heart the spirit of Dr. Whitney's appeal. Although almost ignored by the public and the State, our scientists in the past have won their place in the foremost rank of progress; now that the nation has awakened to the necessity of scientific work, let us take care that while industrial research is not neglected, pure science shall receive that whole-hearted support which hitherto has been denied to it. For upon the due observance of this precept rests not only our scientific culture, but also our industrial existence.

The Control of the Electric Motor-Vehicle Business.

The somewhat interesting question has arisen as to whether motor-car agents shall have a monopoly of the sale not only of petrol motor vehicles, but also of those propelled by electricity. Thus, in the last issue of the *Motor Trader*, in a report of a meeting of the Scottish Advisory Council of the Motor Trade Association, we read that "a clause in a draft of a Bill to be promoted by a Municipal Association under which powers are sought to store, charge, inspect, and repair electric vehicles was considered. It was agreed to write to head office requesting that the clause, if sought to be passed into law, be opposed, and stating that this Council disapproves of the matter being left in the hands of the Electric Vehicle Committee of the Society of Motor Manufacturers and Traders, agents' interests not necessarily being those of that Committee."

The subject is considered by our contemporary of such importance that it devotes a long leader to the matter, from which we are glad to learn that, as the leading organ of the motor traders, it has not hesitated, when finding itself unable to see eye to eye with a certain section of its readers, to speak out, and strongly urge that the best interests of all will be served by motor agents adopting an attitude of sympathy and tolerance towards the problem.

The writer states that a good deal of interest has been created in certain trade circles respecting the promotion of a Bill authorising local authorities to cater for the electric vehicle trade, and that the Bill indicates a very significant development on municipal trading lines. It is pointed out that if the authorities take full advantage of its provisions, their interest in the electric vehicle will exceed the mere operation of charging, and will comprise the repair and maintenance of vehicles and the sale of everything in the electrical line requisite for these vehicles. Our contemporary holds that there is no ground for the assumption that the Bill embodies a deep laid scheme on the part of the public service bodies to appropriate what may become an important branch of the motor trade.

What mainly concerns the opponents of the Bill is the plain issue as to whether the interests of the retail motor trade are threatened. They urge that if the electric vehicle is to command public approval anything like commensurate with the petrol vehicle the motor agent should be taking prompt and adequate measures to secure the business.

Those who believe with us that the electric vehicle is destined to make great progress in this country and that its development has been delayed largely by the lack of charging facilities, maintain that while the motor trade is indifferent to the great promise of this branch of the industry, the offer of the local authorities to supply the stimulating factor in the shape of charging stations and repair and supply facilities is entitled to approval and support.

If we remember rightly, there has already been a little friction between the M.T.A. and the Agents' Section, Ltd., on the one hand, and electrical engineering traders on the other, with regard to the sale of the many electrical accessories associated with petrol cars. It is, therefore, greatly to be hoped that the M.T.A. will not adopt the attitude advocated by its Scottish Advisory Council with respect to electrical motor vehicles, but, rather, the saner course suggested by the *Motor Trader*, a course that will go far in removing any wrong impressions that may exist, and in building up a more favourable view of the M.T.A.'s objects and intentions in electrical circles.

Substitution in Electricity Works.

We print on another page an important memorandum, issued by the Reserved Occupations Committee for the guidance of electrical undertakings in effecting substitution of, and releasing, men for the Army. The demand for young fit men in the Army is apparently so great that most other considerations have now to be set aside, and from the end of this month substitution must be more extensively applied than previously even in electricity works, upon which the manufacture of munitions so vitally depends. We do not know when the memorandum was circulated among members of the I.M.E.A., or whether it has been sent to non-member undertakings, but the Committee issued it as long ago as February 5th. The matter is one of great importance to all electricity undertakings and their employés, whether represented by the Association or not, and there is only a week before the "exceptionally favourable reservation" practice is withdrawn. Therefore we give the document full publicity at once, though it has only come to our hands while going to press.

Our Canals.

It is now many years since we began in these pages our advocacy of the better use of the canals of the United Kingdom in the interests of trade, industry, and agriculture. In season and out of season we joined with others in the demand for modernisation and fuller utilisation of this means of transportation; we described the various systems of electrical operation that had been proposed or adopted in this and other countries. It was commonly believed that the canal system was being strangled or ignored by the railway companies for selfish ends. To-day we see how deplorable it is that suitable measures for improvement were not adopted in time. A past Government referred the whole subject to a representative Canals and Water-

ways Commission, and exhaustive evidence was collected from many quarters, here and abroad, but it is only in war-time, when the Government has the railways under its control, that anything in the shape of definite action is taken. It were waste of words now to spend much space showing how greatly we should have had our tasks simplified during the last year or two, when the pressure upon the railways was phenomenal, if we had also been able to depend upon a continuous traffic of barges on an up-to-date network of waterways. Whatever regrets may be in our mind, we must count it all for future good, as well as helping us in the remaining stages of the war, that Government action has at last been taken which will prevent the matter from ever falling back into its former position. With its control of the railways, the Government naturally assumed control of the railway-owned canals, and it is now announced that the Board of Trade is also taking possession, for the period of the war, of any other canals, non-railway owned, that may be required for essential traffic. It is intended to set up an executive committee to control the canals and all the buildings, barges, machinery, &c., that go with them. Whether railway-owned or otherwise, they will come under this Committee, and every effort will be made to secure for the nation their best use for the conveyance of food, munitions, materials, &c. Truly, this horrifying war is lifting us as a people out of many of our old ruts.

The Good Time Coming.

The Minister of Labour has been giving further expression to his views on after-the-war industry. He continues to speak with the greatest optimism, foretelling a period of booming trade. As we suggested in our reference to one of his earlier speeches, his opinions are those of an authority on the iron and steel trades, and we entirely agree with him in regard to the outlook therefor. Everybody connected with those trades and with the engineering industries, knows well enough what large arrears of work, even of the normal kind, are accumulating. Railway companies, tramway companies, electrical undertakings, &c., are unable to spend what is almost imperatively necessary even on maintenance, and extension work is more often than not only a dream, though verging in cases, we fear, upon nightmare. In all the work of rehabilitation and satisfying the needs of the world, the share of the iron, and steel, and engineering trades cannot fail to be enormous, and it must inevitably spread itself out over many years. But perhaps the most urgent need of all will be the new shipbuilding, upon which armies of workers will need to work at high speed to make up for recent and anticipated losses. Activity in the shipbuilding industries means high-pressure prosperity in iron and steel and engineering industries, and these form so large a part of our national industrial operations that it is reasonable for Mr. Hodge to suggest that every other trade may boom in sympathy. Thoughts such as these respecting the future are, however, overshadowed by the knowledge that we are at the greatest crisis of the war, and may have strange ways yet to tread before the palms of victory are won for Civilisation. We have yet to put all our strength into the contest, and have sacrifices and losses to bear, but beyond it all we trust that there lies unbroken Peace, which will be treasured and understood as Peace never was before in our day. With the period of Peace between the nations, let us have harmony in the industries at home, and, while still at war, prepare in those industries themselves, as the Minister of Labour once again suggests to us, those schemes for greater efficiency of organisation, operation, and production which may go far to secure that harmony.

CANADIAN WATER-POWERS.

The Water-Power Branch of the Canadian Department of the Interior has recently issued a very complete and excellently illustrated description of the developed and undeveloped water-powers of Canada, and we have received a copy from the Canadian Government Trade Offices in Basinghall Street, E.C.

The volume is a reprint of five monographs prepared for distribution in connection with the exhibit of the Dominion Water-Power Branch in the Canadian Pavilion at the Panama-Pacific International Exposition, San Francisco, 1915; it deals in sections with the water-powers of British Columbia, the Prairie Provinces, Ontario, Quebec and the Maritime Provinces. An introduction by the Superintendent of the Dominion Water-Power Branch points out the important part played by water power in the industrial development of the Dominion, which, with the continual advance in electrical science, is expected to become even greater in the future. Practically every commercial centre from coast to coast, except only a few in the middle Prairie Provinces, has abundance of water power available for present and future needs.

Within the provinces of the Dominion of Canada, and excluding the North-West Territories, practically all the Yukon, and the Northern and Eastern portions of Quebec, it is estimated that 17,746,000 H.P. are available, inclusive of Canadian developments permitted by international treaties. The developed powers—for electrical, pulp, milling and other purposes, aggregate 1,712,193 H.P., distributed as follows:—Nova Scotia, 21,412 H.P.; New Brunswick, 13,390 H.P.; Prince Edward Island, 500 H.P.; Quebec, 520,000 H.P.; Ontario, 789,466 H.P.; Manitoba, 56,730 H.P.; Saskatchewan, 45 H.P.; Alberta, 33,305 H.P., British Columbia, 265,345 H.P.; and Yukon, 12,000 H.P. If the present rate of increase in development is continued in the future, the 8,000,000 H.P. estimated to be available within range of present markets will be entirely in use within 15 years.

The Dominion Government controls navigable streams and their water powers throughout the Dominion and the water powers in general of the provinces of Manitoba, Saskatchewan, and Alberta. The administration of all water powers in British Columbia, Ontario, Quebec, New Brunswick, and Nova Scotia is under respective provincial control.

As is well known, British Columbia has been prodigally endowed with natural water-power sites on its numerous rivers and lakes, and it is estimated that within reasonable distance of the cities of Vancouver and Victoria there are possible water-power developments aggregating 750,000 H.P. situated within an area of 20,000 sq. miles; in addition, it is estimated, roughly, that other available powers in the province would bring the total up to 3,000,000 H.P.

Amongst the principal powers developed may be mentioned those of the West Kootenay Power and Light Co., 23,000 H.P.; the Lake Buntzen plant of the B.C. Electric Railway Co., of 84,500 H.P.; and the Jordan River plant in Vancouver Island, of the same company, 25,000 H.P.; the Western Canada Power Co.'s plant at Stave Lake, 26,000 H.P.; Ocean Falls Co., 11,200 H.P.; Power River Co., 24,000 H.P., &c.

The undeveloped powers include many large blocks of 25,000—80,000 H.P., and it is pointed out that great opportunities exist for the electrochemical and electrometallurgical industries, there being many water-powers similarly situated to those in Scandinavian countries, and wonderful possibilities of transport by water freight to suitable markets.

The establishment of electrometallurgical refineries for copper in the neighbourhood of Vancouver or Prince Rupert, where the plants could be erected on excellent water-front sites, would add to the incentive already existing to develop the copper, zinc, lead, and other mineral resources of the province.

In the Prairie Provinces, Lakes Manitoba, Winnipeg, and Winnipegosis are the largest bodies of water. Lake Winnipeg has an area in excess of Lake Ontario, and into it flow the Winnipeg, Red, and Saskatchewan and other rivers, while its outlet to Hudson Bay is the Nelson River. The

northern part of Manitoba is drained by the Churchill River, and the northern parts of Saskatchewan and Alberta by the Athabaska and Peace Rivers. The Winnipeg River is one of the most important power rivers on the continent, and offers many available power sites in proximity to the City of Winnipeg ; a systematic survey of these sites has been carried out by the Government, and six undeveloped sites are noted within 52—74 miles of Winnipeg, these representing 162,700 H.P. under present conditions and over 300,000 H.P. after the storage facilities are provided. The Winnipeg municipal power plant at Point du Bois, 77 miles from the city, will have an ultimate capacity of 76,000 H.P.; its present installation amounts to 51,500 H.P., and may be increased to 119,000 H.P., the energy being stepped up to 66.000 volts for transmission.

The Winnipeg Electric Railway's power plant at Pinewa Channel is 65 miles from the city, and has some 28,200 H.P. installed and a 60,000-volt transmission.

Another concern, the Winnipeg River Power Co., has made arrangements for the immediate construction of a plant consisting of eight 21,000-H.P. generating units on the du Bonnet site, a 110,000-volt transmission to Winnipeg being proposed.

The development of the Bow River above Calgary on suitable lines would give about 50,000 H.P. on six sites ; the Calgary Power Co.'s plant at Horseshoe Falls on this river consists of two 3,750-H.P. turbine units and two 6,000-H.P. units, energy being transmitted at 55,000 volts to Calgary. The same company's Kananaskis Falls plant contains two 5,800-H.P. turbine units.

Some 60 miles above Edmonton a power site on the North Saskatchewan would produce 30,000 H.P. ; at Cole Falls, 25 miles below Prince Albert, a power plant is being constructed for that city. Below the forks of the Saskatchewan at least five power sites are available, one at Grand Forks offering 40,000 continuous H.P.

Passing over numerous smaller developments, we come to the Nelson River, which offers immense prospective water powers, there being 19 power sites that would produce from 77,000 to 235,000 H.P. at the turbine shaft, and give a total of 2½ million estimated H.P.

A summary of the undeveloped and developed water-powers in Ontario shows total potential powers amounting to nearly 5,000,000 H.P., of which 722,000 H.P. are developed, 574,000 being utilised for electrical purposes.

The actually developed power of the Ottawa River and tributaries is 71,000 H.P., Great Lake tributaries 137,000 H.P.; Hudson Bay slope, 22,000 H.P. ; James Bay slope, 30,000 H.P., and International boundary rivers, 462,000 H.P. Probably due to the work of the Ontario Hydro-Electric Commission, Ontario's water powers are better appreciated in this country than those of other parts of Canada ; the work of the Commission is regularly reviewed in our columns, and readers are referred to the latter for details.

The Ottawa River tributaries have provided many moderate sized power developments ; the Northern Ontario Light and Power Co., which supplies the Cobalt district, has two plants of 8,000 and 3,800 H.P. The Ottawa River itself, if regulated, would provide 606,000 H.P. between Lake Temiskaming and Carillon ; about 36,000 H.P. is now in use at the Chaudiere Falls, including about 9,000 H.P. by the Ottawa Electric Co., and 5,000 H.P. by the Ottawa Power Co.

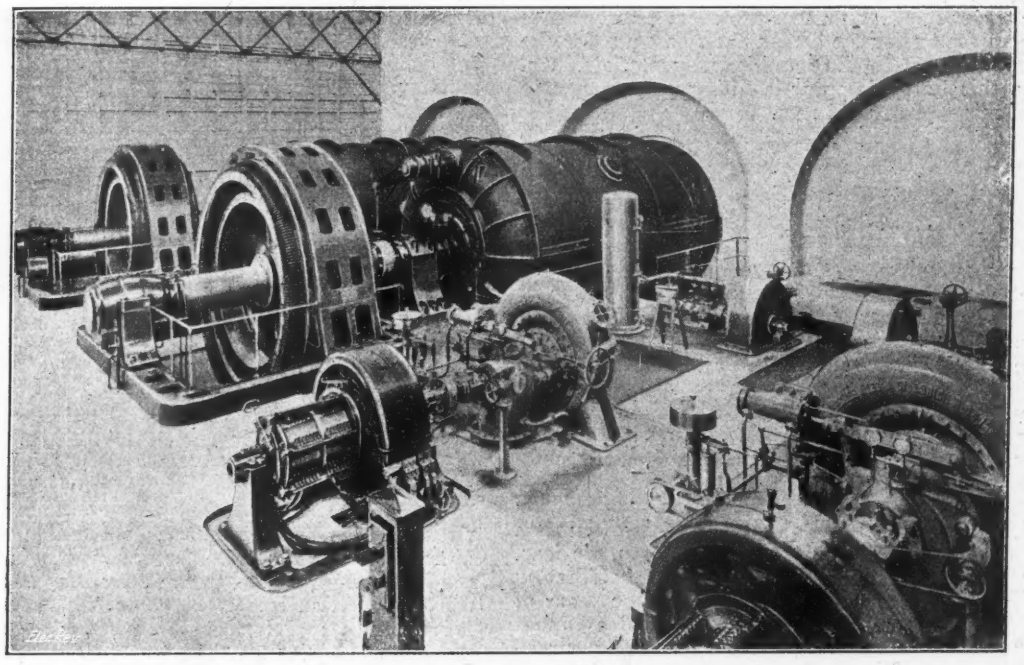
Of the rivers flowing into Lake Ontario, the Trent and its tributaries would easily provide 75,000 H.P. by reason of the works of the Trent Canal, now nearing completion ; about 45,000 H.P. is now developed—the Electric Power Co. having seven plants of a rated capacity of 33,000 H.P. in operation, supplying a large territory along the lake front through 300 miles of 44,000-volt transmission. The undeveloped powers of the Trent system, having capacities ranging from 1,000 to 10,000 H.P., offer fine opportunties for new industries in the vicinity of Peterboro', Cambellford and Trenton.

The total low water capacity of all the Luke Huron tributaries is about 166,000 H.P., neglecting storage, and about 56,000 H.P. is at present developed.

Of the most important undeveloped powers, the French River has three sites, each capable of producing 10,000 H.P. with storage, besides other smaller powers. On the Spanish River, the Canadian Copper Co. has 12,500 H.P. installed for operating its mines and smelters, while, lower down, the Spanish River Pulp and Paper Co. has 10,000 H.P. in use.

About 15,500 H.P. used in the cities of Port Arthur and Fort William is mainly derived from the plant of the Kaministiquia Power Co. at Kakabeka Falls ; these cities are also within easy transmission distance of the Silver Falls on the Kaministiquia River, where some 20,000 H.P. is available, and of the Nipigon River, the 40 miles of which with Lake Nipigon at the head, are estimated to be capable of developing 100,000 H.P.

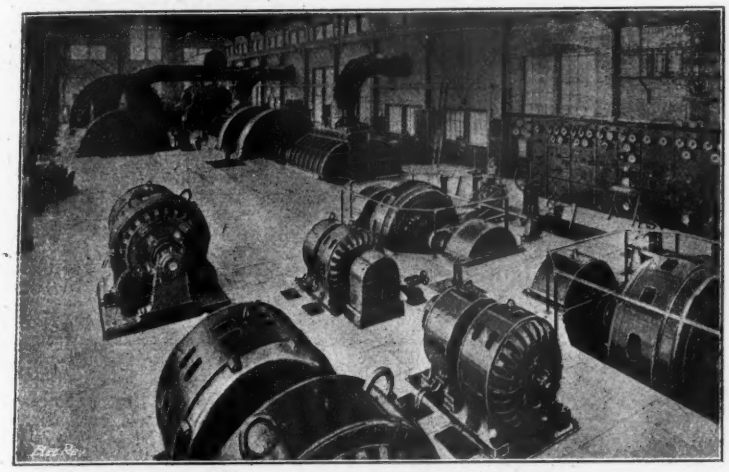
The Winnipeg River (in this province) is roughly estimated to have available some 250,000 H.P., of which only 22,000 H.P. has been brought into use. The White Dog Falls on this river, with suitable storage, would alone produce 75,000 H.P., and several sites on the English River could be developed in blocks of 20,000 to 40,000 H.P. Accurate information regarding the rivers of the James Bay slope is not available, but it may be assumed that 1,500,000 H.P. is physically capable of development.



THE STAVE FALLS PLANT OF THE WESTERN CANADA POWER CO., BRITISH COLUMBIA.

At present, there are two plants of the Northern Canada Light and Power Co. on the Mattagami River with 10,000 H.P. available; also the Abitibi Pulp and Paper Co.'s 19,500 H.P. plant at Iroquois Falls will shortly be at work.

On the international rivers, the Canadian plants on Niagara include those of the Canada Niagara Power Co., with 100,000 H.P.; the Electrical Development Co., 125,000 H.P.; and the Ontario Power Co., 180,000 H.P. On the old Welland Canal, about 12,000 H.P. is developed,



Power Plant of the Granby Consolidated Mining Co., B.C.

supplying industries in St. Catherines, Merritton, and Thorold. The Dominion Power and Transmission Co. also has a 57,000-H.P. plant at Decew Falls which utilises the canal water, and transmits energy at 10,000 to 40,000 volts to a number of towns in the Niagara peninsula; the commercial prominence of Hamilton is largely ascribed to the power facilities offered by this company.

Between Lakes Superior and Huron is a difference in level of 20 ft., and the minimum flow at St. Mary's Rapids would produce 90,000 H.P., half of which belongs to Ontario; this power has partly been used in Canada and the States—in the former, about 17,000 H.P. is used by the Algoma Steel Corporation and allied industries.

The St. Lawrence river between Lake Ontario and Lake St. Francis offers a development of 1,000,000 H.P., of which 500,000 H.P. would be available for Ontario.

Such a development would require the co-operation of the United States, and be costly; moreover, a sufficient market for the power does not exist.

The undeveloped water power of Quebec represents about 5,000,000 H.P.; the developed power amounts to 520,000 H.P., of which 370,000 H.P. is used in the form of electrical energy.

There are many undeveloped falls and rapids on the Ottawa River (in Quebec); the Quinze River (a part of the Ottawa River) has some 90,000 H.P. available, and the Kipewa River 50,000 H.P. The Lievre River, a tributary of the Ottawa River, is estimated to be capable of generating 85,000 H.P., of which less than 10,000 is in use, while the Gatineau River would produce 225,000 H.P.

The Cedars Rapids, about 35 miles from Montreal, on the St. Lawrence, are capable of generating 160,000 H.P.; at present, the Cedars Rapids Manufacturing and Power Co. is producing 90,000 H.P., of which 60,000 H.P. is being transmitted to aluminium works at Massena and the remainder to Montreal.

On the opposite side of the St. Lawrence, the Canadian Light and Power Co.'s plant at St. Timothee furnishes 20,000 H.P. to Montreal for traction, and can be extended to 50,000 H.P. Some 13,000 H.P. is also developed on the Soulanges Canal for use in the city.

A diverting canal between Lakes St. Francis and St. Louis would give a head of 80 ft. and possibilities of over 100,000 H.P.

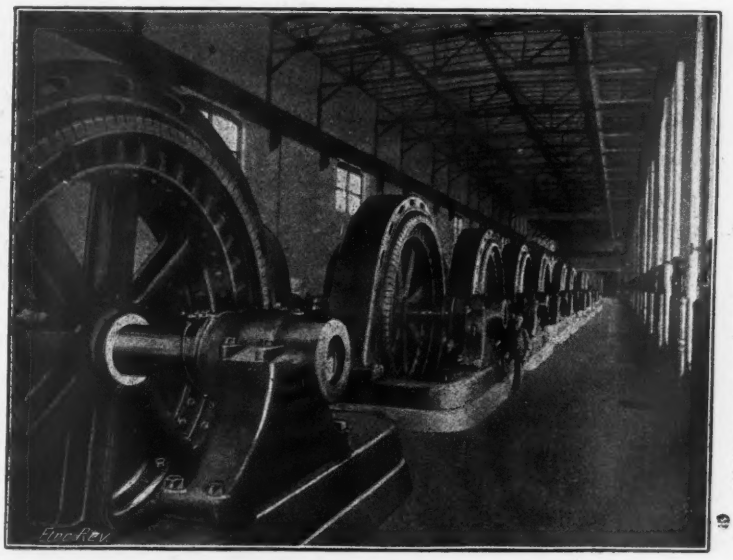
Still nearer Montreal, at Lachine, the rapids are estimated to be equivalent to 400,000 H.P., but only a portion is available for development, and an existing plant supplies 13,000 H.P. to the city, which also receives 20,000 H.P. from a plant on the Richelieu River at Chamley, and a certain amount from the well-known Shawenegan Falls development, nearly 100 miles distant on the St. Maurice River, so that the city receives in all about 126,000 H.P. from water developments. The St. Maurice River has possibilities of 650,000 H.P.; the most southerly power is at Le Gres Falls, 15 miles north of Three Rivers, where 60,000 H.P. is available.

The entire water rights of the Shawenegan Falls are owned by the company of that name; the plant is capable of generating 155,000 H.P., which is used locally in the aluminium, carbide and manufacturing industries, and transmitted to Montreal, Three Rivers, and other towns.

Situated about 12½ miles above the Shawenegan Falls are the Grand Mere Falls, with 100,000 H.P. available, which is being developed by the Laurentide Co. At La Tuque, on the same river, is a fall capable of developing over 75,000 H.P., and there are a number of smaller power sites.

In the vicinity of Quebec City are numerous undeveloped, or partly developed, powers, and the Saguenay River, 120 miles north of the city, provides two sites for developments of 300,000 H.P. continuously, which, with storage in Lake St. John, could be more than doubled. The Quebec Development Co. is the owner of water rights on this river.

On the North Shore of the St. Lawrence, between the Saguenay and the Atlantic, the country is scattered with large undeveloped water powers, the country itself being undeveloped; it is estimated that over a million H.P. is available.



Winnipeg Electric Railway Power Plant at Pinawa.

[In New Brunswick there has been developed about 13,000 H.P., 56 per cent. being for saw, grist, &c., mills; one plant has 3,800 H.P. installed.

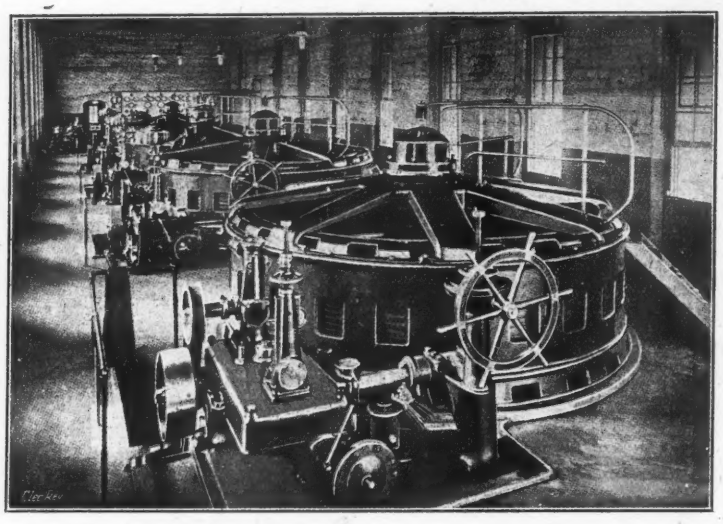
In Nova Scotia about 24,000 H.P. has been developed,

mainly for pulp and paper making, though a number of small hydro-electric plants supply town lighting, &c.

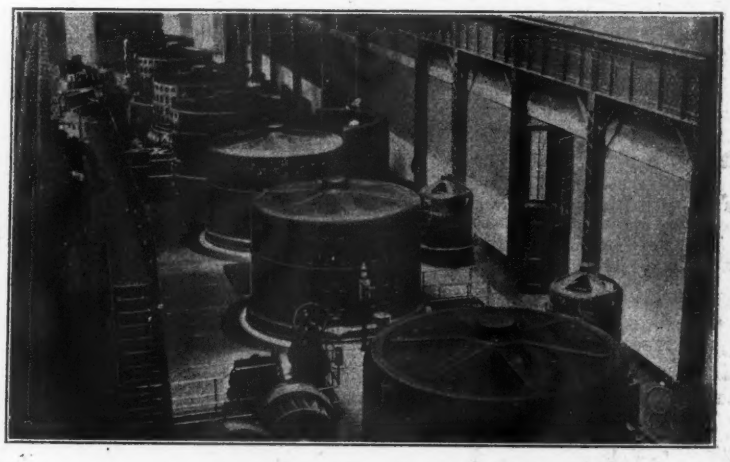
There are two outstanding undeveloped power sites in New Brunswick—Grand Falls on the St. John River and Grand Falls on the Nepisguif River ; as regards the former, an 80,000 H.P. development has been planned, while the Pokiok site on the same river is said to be capable of developing 30,000 H.P.

The other Grand Falls, about 20 miles from the town of Bathurst, could provide some 10,000 H.P. In Nova Scotia the Mersey River is considered to be capable of developing 30,000 H.P. on several sites, while lesser developments are possible on other rivers ; generally speaking, there are a great number of minor power sites scattered over the Maritime Provinces. Though we have necessarily touched very briefly on the contents of this interesting volume, which contains some 360 pages of descriptive and illustrated matter, together with maps, &c., the reader will probably share with us the opinion that no other country in the world offers such immense scope for the development of water power, and of the industries — such as electro-chemical, electro-metallurgical, and pulp manufacturing—which are peculiarly dependent on a steady natural source of power.

It cannot be doubted that the water powers of Canada are an asset of incalculable value in the Empire's resources.



HOUND CHUTE POWER PLANT, NORTHERN ONTARIO LIGHT AND POWER CO.



POWER PLANT OF THE ELECTRICAL DEVELOPMENT CO., NIAGARA FALLS.

NEW ELECTRICAL DEVICES, FITTINGS, AND PLANT.

Readers are invited to submit particulars of new or improved devices and apparatus, which will be published if considered of sufficient interest.

Multiple Cable Glands for Watertight Bulkheads.

THE rapidly increasing adaptation of electrical energy to all kinds of auxiliary services on board ships of the Navy, as well as the mercantile marine, has confronted the shipbuilder and electrical engineer with problems to be solved which in days when the use of this form of energy was confined to electric lighting did not arise. One of these problems, and that not of least importance, is how to ensure water-tightness of those bulkheads through which electric cables have to pass. Some idea of the difficulty of maintaining these bulkheads watertight may be realised when it is stated that in large warships the number of individual cables passing through some of the more important bulkheads is not far short of 100. Up to the present, the method adopted has been to pierce the bulkhead with a separate hole and fit a gland for each separate cable. After threading through the cable, these glands are made as far as possible watertight by means of asbestos and grease, or in Naval practice a metallic packing pressed in around the cable by brass sleeves and nuts.

This system has many drawbacks, the chief of which are as follows:—(1) Where the number of cables is large the strength of the watertight bulkhead is greatly impaired by reason of the correspondingly large number of holes which have to be bored. In many cases doubling plates have to be riveted to the bulkhead to compensate for this weakening of the structure. All this means extra labour on the part of the ironworkers, riveters, and drillers.

(2) Watertightness of these glands depends upon the thoroughness with which the packing has been carried out —a matter depending largely upon the skill and conscientiousness of the man employed. Continuance of this state of watertightness depends upon the gland nuts remaining tightly screwed up in spite of vibration or similar causes; shrinking of the packing material due to its drying up in places exposed to a warm atmosphere must also be followed up by subsequent retightening of these nuts if the glands are to remain watertight. Where the number of glands is exceptionally large, human nature being what it is, the periodical inspection and retightening of slack nuts is almost certain to be neglected.

(3) Where lead-covered cables are employed, as is the practice in warships, great care must be exercised to ascertain that the packing material has been uniformly distributed round the cable, otherwise tightening up of the gland sleeves and nuts in order to compress the packing material will not render the gland watertight. Again, too great pressure may, and does often, force the packing, particularly if it be metallic packing, into the lead sheath of the cable, and this may not be discovered at the time unless the damage done is sufficient to force the lead sheath through the rubber insulation and earth the cable.

All the foregoing objections to the present form of so-called watertight gland can be overcome by the adoption of a multiple cable gland, employing a plastic compound composed of the same or similar material as is at present used for the sealing chambers of paper insulated cables. By employing this type of gland, a much smaller number of holes, though of somewhat larger diameter than hitherto, suffices. Stiffening of bulkheads except in unusual cases, such as very thin bulkheads, becomes unnecessary. The knowledge that the gland is perfectly filled with packing material becomes a certainty, as it can be forced in under pressure until it exudes through inspection holes. Initial watertightness and continuance of the same in no way depends upon nuts or similar devices remaining tightly screwed up, and those other than the fixing nuts may, in fact, be removed altogether without impairing the efficiency of the gland.

Fig. 1 shows in part-section the side view of a gland of the foregoing description in position on a steel bulkhead, the top half being cut through to illustrate more clearly the cables passing through the gland. No. 4 is a piece of steel tube fitted in position in the bulkhead (1), and secured and made watertight by means of the nuts and washers (2) and (3), which are screwed up tightly against an asbestos insertion joint smeared with red-lead and placed between the washer (3) and the structure (1), to which it is fitted; this joint serves to prevent the passage of water in that direction between one compartment and another. In each end of the steel tube (4), in which a recess has been arranged, are fitted

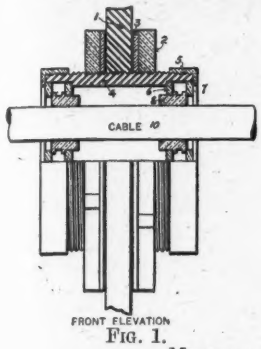


Fig. 1.

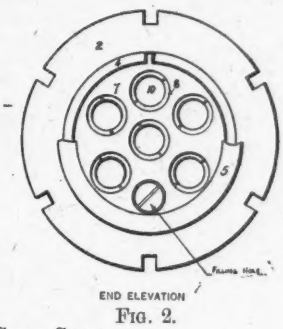
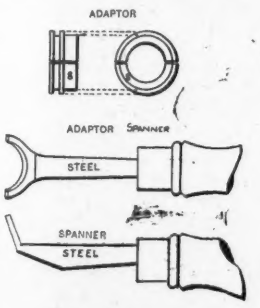


Fig. 2.

Multiple Cable Gland.

two end plates (6) and (7), designed so as to be fitted in one position only, and bored with holes somewhat larger in diameter than the cables. In the inner end plate (6) at each end of the gland are fitted split adaptors (8), which are slipped over the cables after they have been passed through. The outer end plate (7) is then placed in position against the adaptors, and both plates and adaptors are locked in position by means of end ring nuts (5), in such a way as to prevent their being forced out while subjected to an internal pressure during the course of filling. Any subsequent slackening of these end ring nuts (5) will not affect the watertightness of



Figs. 3 and 4.

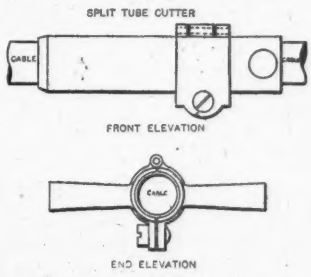


Fig. 5.

the gland, as the adaptors (8) and inner end plates (6) are held securely in place by the sealing compound which adheres to every portion with which it comes into contact.

Fig. 2 shows an end view of the gland arranged for the passage of six cables; the end ring nut (5), being broken, shows the slot in the steel tube (4), which permits of the plates (6) and (7) being fitted in one position only; at the bottom of the end plates a filling aperture is arranged, into which the filling pump is fitted, the compound being forced in at the bottom of the gland in a liquid state. An aperture being arranged in both ends of the gland permits of the filling operation being carried out from either side of the bulkhead as found most suitable.

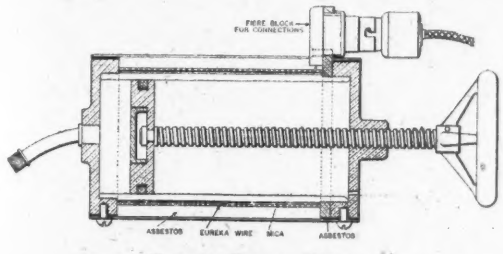


Fig. 6.—Filling Pump.

Fig. 3 shows an end and side view of the split adaptor (8), and fig. 4 a special spanner for use when it is desired to withdraw the adaptors from their position in the gland. Fig. 5 is a split tube cutter, by means of which a damaged cable can be withdrawn from the gland and replaced. When it is desired to replace a cable which is fitted in a sealed gland, the adaptors through which the cable passes are warmed by means of a blow-lamp, and with the adaptor spanner drawn from their position. The split tube cutter is then clasped over the cable and heated at the cutting end, after which it is forced through the compound in the gland, completely severing from the remainder the compound in direct contact with the cable to be withdrawn. The old cable then being free can be removed, leaving the hole free for the passage of the new one. After the new cable has been passed through, and the adaptors have been again placed in position, the pump being charged and fitted in the filling aperture, the gland is heated uniformly until the sealing medium resumes a liquid state, when an additional charge of the compound again renders the gland watertight.

Fig. 6 shows the general arrangement of the filling pump. The compound, having been heated in a suitable receptacle, is poured into the pump chamber by means of a filler; a heating element wound round the chamber generates sufficient heat to maintain the compound almost at boiling point; when the pump is fitted in position in the gland the piston is forced into the chamber by means of the screw, thereby forcing the compound into the gland under considerable pressure, with the result that not only is the gland sealing chamber filled, but also all crevices and clearances, making the passage of water, even when subjected to considerable pressures, impossible.

Summary of Advantages and Disadvantages of Present and New Types of Gland.

Present Gland.	*Multiple Cable Compound Gland.*
1. Weight of glands required, 100 per cent.	1. 60 per cent.
2. Holes to be bored in fixed structure, 100 per cent.	2. 20 per cent.
3. Packing operations, 100 per cent.	3. 10 per cent.
4. Cost of packing material, 100 per cent.	4. 25 per cent.
5. Space necessary for fitting, 100 per cent.	5. 60 per cent.
6. Cost of glands, 100 per cent.	6. 90 per cent.
7. Water test (uncertain) depending on workman's skill, and finally on amount of vibration and shrinkage with heat.	7. Tested to 20 lb. with water for several days, and is not affected by vibration or shrinkage.
8. Possibility of failure to maintain its effectiveness due to the large number of nuts and joints to be kept tight.	8. Greatly reduced, being applicable only to fixing nuts, which are reduced to 20 per cent.
9. Great care must be exercised to prevent injury to the cable sheathing by the watertight packing.	9. No such danger, as compound is liquid and subjected to uniform pressure.
10.—Difficulty of access to adjust glands or replace cables due to the method necessary of grouping the glands in the available space.	10. Cables being arranged in groups of 10 as a maximum, and passing through one gland, permit of the glands being arranged more suitably.

The Multiple Cable Compound Sealed Gland forms the subject of Letters Patent, and is manufactured with all accessory appliances by Messrs. W. McGeoch and Messrs. Bradbury, Glasgow and Birmingham.

Motor Vehicle Inspection Lamp.

Messrs. Simplex Conduits, Ltd., of Garrison Lane, Birmingham, have produced a very useful electric inspection lamp for the rapid examination of the inaccessible parts of chassis or engine. The lamp is strongly made, in two patterns; one is 26 in. long, with the lamp guard 1¼ in. in diameter, fitted with a switch in the handle; the other is only 15 in. long, and the lamp guard is only ⅞ in. in diameter, so that it will pass quite small apertures. The device is sent out wired complete, and can be supplied with lamps of high voltages for garage and factory use, or with low-voltage lamps for running off 6 or 8 or 12-volt batteries for use on the road.

D.C. Lighting and A.C. Power from one Set.

Messrs. T. W. Broadbent, Ltd., Huddersfield, have introduced a three-phase alternator ("T" type) designed specially for the purpose of motor driving in mills, &c., a novel feature of which is that the continuous-current generator supplied as its exciter is large enough to provide, in addition, for the lighting of an average sized electrically-driven works, factory, or mill. This system of combining an alternator and a dynamo for the respective purposes of motor driving and lighting offers many practical advantages. By this means are combined the simplicity and reliability of the three-phase current for power transmission, and the good pressure regulation of continuous current for lighting. In practice, the ratio of the demand for lighting to that required for power, in such cases, does not vary greatly; and the relative proportions of the machines have been arranged to suit ordinary conditions. The continuous-current generator can, however, be made relatively larger or smaller, as may be necessary to suit special requirements. The standard winding of the alter-

nators is for 460 volts, and a frequency of 50 cycles per sec. The exciter is compound wound for 115 or 230 volts. As shown in the accompanying illustration, each set is mounted

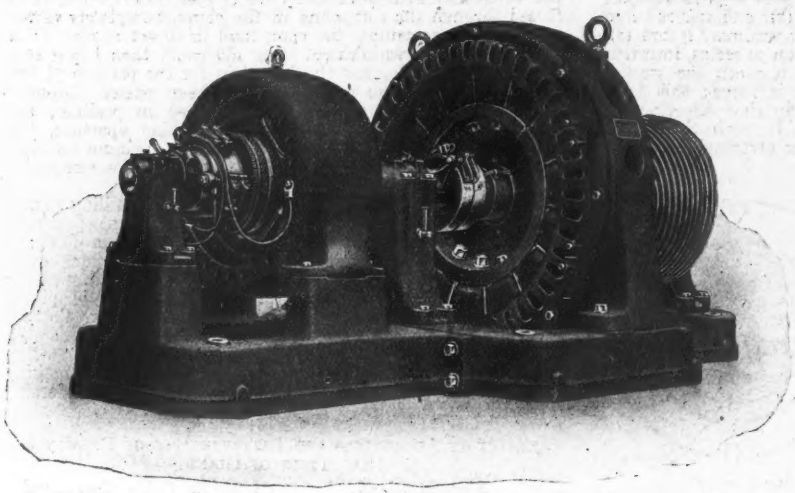


FIG. 7.—BROADBENT "T" TYPE POWER AND LIGHTING SET.

on a combined bedplate, and the outputs at present listed range from 60 to 400 KW.

CANTIE PATENT FUSE GEAR.—In our last issue, in referring to the above on pp. 174 and 180, we should have stated that these fuses are made for capacities up to 150 amps. per way, not being limited to the sizes mentioned.

CORRESPONDENCE.

Letters received by us after 5 P.M. ON TUESDAY *cannot appear until the following week. Correspondents should forward their communications at the earliest possible moment. No letter can be published unless we have the writer's name and address in our possession.*

American and English Research.

The summary, on page 138 of your journal, of Mr. Fleming's lecture on American research makes interesting reading, and when compared with the article by Dr. Whitney, printed in the *Electrical World* on January 6th last, is all the more so.

Dr. Whitney, chief of the research department of the American G.E. Co., apparently emphasises the point that, compared with English and German research, his own country lags behind; whilst Mr. Fleming evidently considers that we are much behind America. Neither of these eminent engineers appears satisfied with the state of affairs in his own country, and, quite rightly, they are endeavouring to alter this. Dr. Whitney's article is complete, whilst Mr. Fleming's is only partially reported, so that one cannot form a definite conclusion on his remarks. May I ask if you could publish a summary of Dr. Whitney's article, as I think it would greatly interest your readers?

The closing remarks of Mr. Fleming, where he speaks of the need and importance of combination, are worthy of much thought. One wonders where in this country are the firms who could successfully enter into competition for really big jobs with such companies as the American Westinghouse and G.E. Co., the German A.E.G., and the Siemens group. If, as a nation, we do not seem to look with much favour on combines—and some of those already existing here are highly successful—we ought to do something definite to secure a greater degree of combination and co-operation than has hitherto been the case; otherwise the future for electrical engineering, at any rate, does not seem to be particularly rosy.

A faint gleam of hope arises, however, after perusing the B.E.A.M.A. report.

W. H. B.

[An abstract of Dr. Whitney's article appears on p. 223 of this issue.—EDS. ELEC. REV.]

Localising a Fault.

With regard to the correspondence under the above heading, may I point out that although Mr. Chubb sheds light on one of the probable sources of error in the test given by Mr. Wardle, there are still two others, either or both of which will completely upset both the tests so far given. These conditions are (1) variable resistance fault, (2) partial or complete burn-out. The following procedure, identical in part with that of Mr. Chubb, although not professing to be a completely satisfactory solution of the problem, will be found to deal in a rather more comprehensive manner with faults of the "no return" type.

The instruments used are the usual portable milli-voltmeter, ammeter, and ignition accumulator.

The resistance in ohms of the circuit made up of (1) "bad" cable up to fault, (2) earth, sheathing, or "shorted cable" return, (3) the fault itself, is measured from each end of "bad" cable by sending about 10 amperes round this circuit, and measuring the "drop" across its ends. The two resistance values so obtained are converted into equivalent yards of the "bad" cable, or, in the case where a "shorted cable" is used for return, into equivalent yards of route (lead and return). These two distances laid off from their respective ends will each overlap the fault by an amount equivalent, in the case of the earth return, to the resistance of the fault plus that of the earth return, and in the case of the "shorted cable" return, to the resistance of the fault only.

Taking the case of the earth return: Provided that the fault resistance remains constant during the two tests, that the resistances of the two earth returns are equal or insignificant, and, in the case of an earthed burn-out, that the fault resistances from the two sides of the burn-out are equal, then the two distances will overlap the fault by exactly equal amounts, and therefore the fault will lie at the point midway between the marked-off points. The formula for this test (The "Overlap") is merely for the purpose of finding this mid point; that is:—

$$\text{Distance of mid. point from end 1} = \frac{\text{Equiv. length by test from end 1} - \text{ditto from end 2} + \text{length of } \textit{bad} \text{ cable}}{2}$$

It is, of course, obvious that the assumptions made in this test are, in the majority of cases, totally unjustifiable, especially so in the case of the "earth" return. In the case of the "shorted cable" return the assumption regarding the equality of the return paths is eliminated, but the assumption regarding the constancy and equality of the fault resistance still holds. Practically the only case where this formula will give the correct position of the fault is that in which the copper and sheathing, or the two coppers, have been welded together into a constant, low-resistance fault. Exactly the same observations apply to both the tests already given.

In the above test, however, the two equivalent lengths obtained do give us the absolutely definite information that the fault cannot lie farther from either given end than the equivalent length obtained by test from that end, and, provided either of the equivalent lengths falls within the actual length of bad cable, this information restricts the range of further search.

In seeking to definitely narrow down the faulty length in this manner, advantage should be taken of every alternative circuit, that is, if all three cores are "down" circuits should be made up with each core and earth (or sheathing), and with each pair of cores, and that equivalent length taken which has the *lowest* value.

"Bridge" methods may, of course, be used instead of "drop" methods for obtaining the resistances, but heavy test leads then become necessary, and trouble is introduced due to contact resistances.

Where service tappings exist on the bad cable, the following modification is preferable to the above. It includes all the information given in the regular "Overlap," it is serviceable in a much greater number of cases, and its behaviour proves its trustworthiness or otherwise. The modification consists in correcting the "drop" reading for "fault resistance," and in actually measuring the "drop" per yard of route, instead of presuming earth paths negligible or equal.

The testing current is maintained at a steady value throughout the test. The total drop is taken at feeding end in ordinary way, sheathing being used for return path. Voltages are now taken between core and sheath at each service tapping on "bad" cable, and on far end of cable itself. Starting at feeding end, these readings should be carefully noted with maximum and minimum values of each, and amount of variation. If the variation is equivalent to any considerable number of equivalent yards of bad cable, the test must be treated with great caution. Should the far-end reading show an initial deflection of, say, 0.1 volt, immediately and steadily decreasing to, say, 0.01 volt., the fault contains a break, and it is the E.M.F. of the fault that is being measured instead of the "drop" in the fault due to testing current. In such a case the fault must lie in that span between two service tappings whose far end is the first point to show the effect.

Where no break exists, the succession of readings will show decreasing values until the fault is passed, being then constant at the value of the "drop" in the fault. Thus the fault must lie in that span whose far end is the first to show the constant reading. Decreasing values throughout show the fault to lie between the last two points. Constant values throughout indicate that the fault lies close up to the feeding end.

The difference between any two decreasing readings (not to include the constant reading) divided by the distance between their testing points, gives the drop per yard of route. The "constant" reading (minimum value, if slightly variable) gives the "drop" in the fault itself.

Total drop less fault drop, divided by drop per yard of route, gives yards to fault from feeding end. The same applies to the "bad" span; drop at near end, less drop at far end, divided by drop per yard of route gives yards from near end.

Repeat the whole test, feeding in from the other end of the bad cable. Then, if careful *minimum* values of fault drop have been taken, and distances obtained should overlap, the fault may confidently be sought within the overlap. Differences in value of "fault drop" obtained from the two ends, if constant, show a break at the fault.

If the section to which the fault is finally narrowed down is of any considerable length, uncover the cable at the most likely spot near the centre (joint box, &c.). If there are no joints or other probable bad spots, open out at the centre and connect the millivoltmeter across two or three feet of the sheathing of bad cable (testing current on as before, returning by sheathing); this will give by the direction of the deflection (moving coil instrument), the direction of the current in the sheathing, which must always be *away* from the fault, if positive pole of battery is connected to core. If no deflection is obtained, the fault lies nearer the feeding end. As a precaution, the testing current should be made and broken in order to make sure that the deflection obtained is due to testing current, and not to stray currents. Having found in which direction the fault lies, the same method is pursued in a second inspection hole opened out midway between the centre and the end of bad span, and so on until fault is found. Where a joint box is uncovered, it is opened and a compass laid directly on the copper, thus getting the direction of current in all cores branching at the joint, and so the direction of current travelling *to* the fault.

In all this it is presumed that it is impossible to obtain a sound return cable, and that the various compass and induction-coil methods have been found useless.

J. A. Beckett.

Spenborough Electricity Works, Cleckheaton,
February 13th, 1917.

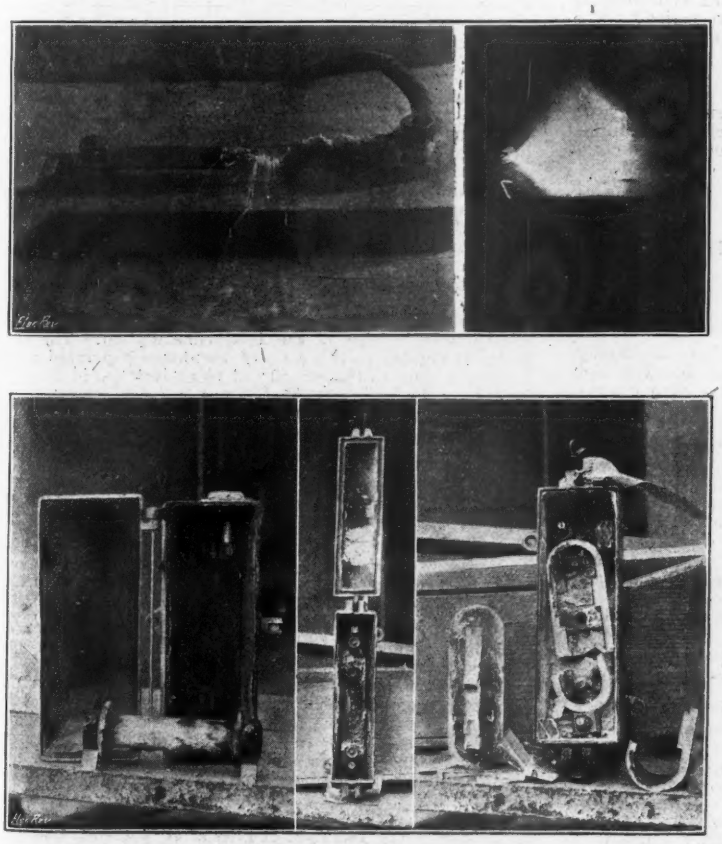
Fuse Failures.

Following the publication of Mr. Baynes's article and illustrations on the blowing of fuses, I beg to enclose for your perusal a few photos which were obtained some time ago. They were taken with a view to determine whether or not asbestos-covered wire was appreciably better than bare wires, and also whether certain fuse boxes could withstand a short-circuit current. The plant in use consisted of a 300-kw. 500-volt generator, controlled by fuses only. The test fuses were connected only a few yards from the dynamo terminals. The circuit was closed by means of a special quick-make device fitted up for the purpose, and the length of break in the test fuses was about 4 in., whilst the break in the fuse boxes varied from 4 in. to 8 in.

I am not sure whether any of the prints are suitable for publication, but you are quite at liberty to use them if you should consider them of interest to your readers.

W. H. B.

[We reproduce herewith a selection of the photographs. The upper views show the blowing of 20-amp. 500-volt tin fuses, asbestos covered and bare; the lower views show the condition of the fuse boxes (25 to 50-amp. capacity) after being fitted with a wire of the maker's rating, and blown on a dead short.—Eds. Elec. Rev.]



Views Illustrating Tests on Fuses.

Telephones and War Surcharges.

We think it only right on our part to correct the impression conveyed in the report of above in your last issue.

Our counter-claim was in respect of rental charges and non-removal of 64 wires which cross our premises (spare ground which we now wish to build upon), and are seriously interfering with our business, as they take up, roughly, 36 sq. ft., and are only 25 ft. above ground. The matter was reported, and commented on by you, in your issue of November 24th last, under the title of "Wayleaves."

Imagine our surprise when, at the hearing of the action, the plea as stated was propounded, and what seems to us extraordinary is that the Crown, having taken over a commercial undertaking, can repudiate the contracts and liabilities just as it chooses.

Surely there must be quite a host of people who, relying upon the well-known commercial status of the old National Telephone Co., are in a most unsatisfactory position, their contracts being only so many "scraps of paper." We have no intention of allowing the matter to rest in its present stage—in fact, such a thing is impossible.

The Stanneries Metal Works.

London, S.E., *February 19th*, 1917.

Curious Trouble with Lead-Sheathed Cables.

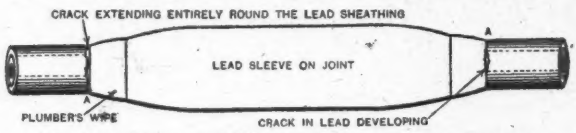
I have lately experienced a new trouble in connection with a route of about three miles of E.H.T. trunk mains, and think, perhaps, the information I am sending herewith may be of interest to your readers. Some of them may have had a similar experience, and may be able to explain the cause of the destruction of the lead sheathing at the end of the plumbed joints of the four concentric lead-covered cables to which I refer. They may also be able to suggest a remedy for the trouble.

The cables, which are four in number, are paper insulated and plain lead sheathed, drawn into a duct system. The manholes, most of which are in the footway, are of brickwork, and the cables, where they pass through the manholes, are always supported with iron hangers attached to wood battens, which, in turn, are spiked in brickwork. As an additional precaution against damage, each cable is separately served over the entire length of the manhole with a covering of woven asbestos, this material being 4 in. wide and about ¼ in. thick, and wound over the cable with a half lap. The joints which are in the manholes are covered with a sleeve of drawn lead, which is joined at each end of the joint to the lead sheathing of the cable by a wiped joint of plumber's metal, as shown in the attached drawing. When the asbestos covering was removed it was found in a number of cases that the lead sheathing of the cable was broken at the point A. In a few cases the lead had parted entirely over the circumference of the cable, leaving a gap of about ⅛ in. wide. In the majority of instances, the crack did not extend all round the cable, nor was the lead cracked through its entire thickness. These cracks were found to be in every case exactly at the end of the plumbed joints at the point A of drawing, where the plumber's "wipe" joined the cable sheathing. The length between joints varies from 100 to 150 yds. The appearance of the crack showed no signs of electrolytic action or melting,

and might have been caused by mechanical means, such as continued bending, there being no thinning down or wastage of the lead.

In five cases the lead was actually parted, there being a space of ¼ in. in width between the sides of the gap. In all these cases the defects were at one end of the joint only. In three cases defects were found at both ends of the joint, but the lead was not entirely parted. In five cases the trouble was at one end, but in none of these was the lead parted. In one manhole, referred to later, all four cables were found to be defective. In other manholes, sometimes one and sometimes two cables were affected.

The positions of the manholes varied. Several of them were situated in quiet suburban streets with very little traffic, but the manhole in which all four cables were defec-



Straight Joint on 7,000-volt Concentric L.S. Cable.

tive was in the carriageway of a main artery in London, and subject to a continuous stream of traffic of the heaviest character—motor 'buses, steam lorries, and traction engines with heavy trailers—and the vibration of the brickwork of this manhole was very pronounced.

The cables have been laid for a number of years, and our tests indicate that the trouble has probably only arisen during the last few months. The question of vibration has been considered, but, in view of the fact that several joints are damaged on one side only, and in many cases, as already mentioned, many of the manholes were in very quiet streets, and in other streets where traffic was heavy only one of the four cables appears to have been affected, it is open to question whether this is due to vibration or some other cause.

G. W. Partridge.

London, S.W., *February 14th*, 1917.

British v. German Turbines.

May I beg leave to take up a little of your space in connection with the above matter?

Mr. Nichols Moore appears to be convinced that German A.E.G. turbines are in advance of British-made turbines; I wonder if Mr. Moore has ever heard of some of the troubles experienced with these machines. For instance, has he ever heard of two turbo-blowers in South Wales that had recently to be rebladed after some three years' use? or of a turbine in Spain that had to be reconstructed entirely by an English maker in order to get it to work at all? Is Mr. Moore aware that one turbine on an important South African mine has completely failed during the guarantee period? The Shanghai and the Melbourne turbine failures are, of course, well known. Possibly Mr. Moore has not yet heard that several large turbines of German make in Japan are now being rebladed by British turbine makers.

When Mr. Moore's Newport turbine has run a few years he will no doubt know more regarding cracking of turbine blades, and be a sadder and, possibly, wiser man.

L. M.

BOILER-HOUSE OPERATION AND MAINTENANCE.*

(*Concluded from page* 194).

The grading of the coal improved matters, but the solution was in the design of the stoker arch (see fig. 5). The high arch gives equally good results with slack and large crushed coal, and it is believed better results still would be obtained if a still higher arch could be used.

With large crushed coal, clean boilers can steam continuously at 25 per cent. overload, and give 78-80 per cent. continuous efficiency; burning slack, the efficiency is 66-75 per cent., depending on dust. The coal (Cornelia) analyses 7 per cent. moisture, 22 per cent. volatile, 52.5 per cent. fixed carbon, and 18.5 per cent. ash.

As regards boiler-house losses, the fireman can readily obtain a good CO_2 chart by running a heavy fire at the back and allowing unburnt coal to go over with the ashes, and by running on reduced draught and thus reducing evaporation. The average percentage of CO_2 is, roughly, the same for all stations, viz., 10.5 per cent. when the boilers are steaming. With the same CO_2 the boiler efficiency will naturally vary with uptake temperature.

It has frequently been stated that it is possible to obtain the same efficiency with low as with high-value coal. In commercial working this is impossible, even with the same CO_2 and uptake temperatures; for instance, when burning either Cornelia coal at Vereeniging or Schapenrust coal at Brakpan, the chimney losses are never less than 14.5 per cent., whereas when burning Witbank district coals under exactly the same conditions of CO_2 and chimney temperature the chimney losses are about 12.7 per cent. Furthermore, it is practically impossible to obtain the same furnace efficiency, as the unburnt carbon in the ash is considerably higher with low-value coals containing a high ash percentage, and there is a further loss with those low-value coals which require saturating with water due to the evaporation of the added moisture.

The unburnt carbon in the ash is between 4 and 6 per cent. of the energy value of the coal; the authors put radiation losses from boiler and economiser casings at 5 to 6 per cent., for the isolated boiler unit type.

Table IV shows the distribution of coal energy. In all calculations the higher calorific value has been used; with the lower value the efficiencies would be somewhat higher.

TABLE IV.—Weighted Average Boiler-house Efficiency and Losses.

	Brakpan.	Rosherville.	Simmerpan.	Vereeniging.
Energy to water ...	71·2 %	74·6 %	76·1 %	74·8 %
Chimney losses ...	15·5 %	13·2 %	12·7 %	14·7 %
Loss in ashes... ...	6·5 %	4·5 %	4·5 %	5·5 %
Radiation and banking	6·8 %	7·7 %	6·7 %	5·0 %
	100·0 %	100·0 %	100·0 %	100·0 %

The authors say that it is difficult to arrange an equitable basis for a bonus scheme per fireman, and they therefore rely on intelligent supervision.

TABLE V.—Totals and Weighted Average Maintenance Costs—1915 Results.

—	Costs.	Cost per boiler installed.	Cost per ton of coal burnt.	Cost per U.S.O.
	£	£	d.	d.
Brickwork	2,943	28·90	·690	
Boiler mountings ...	1,025	10·00	·242	
Miscellaneous repairs to boilers...	1,456	14·27	·344	
Dumping bars and ash plates	729	7·15	·172	·00525
Stoker gear boxes and chain-grate stokers ...	2,331	22·87	·548	
Internal and external cleaning of boilers and economisers	8,021	78·70	1·880	
	£16,505	£161·89	3·876d.	·00525d.

102 boilers installed. Total tons coal burnt, 1,023,613.
Total steam hours, 505,520. Total U.S.O., 754,681,000.

The Vereeniging power station boiler maintenance costs for 1915, under the same headings, were:—£2,816, £140.80, 1.762d., and .0025d. respectively, with 20 boilers installed; total tons coal burnt, 383,458; total steaming hours, 137,120; and total U.S.O., 269,400,000.

Load factor has a considerable effect in obtaining efficient results, but "utility" factor has also a powerful effect. For instance, a 100,000-kw. station, which has to be prepared to supply that load if required, but which never materialises, may have a load factor of 80 per cent., even though the maximum load called for only, say, 50,000 kw. The utility factor is relatively low, although the load factor is high.

The standing losses are those of a station of 100,000 kw., and these divided over the units sent out will represent a considerable fraction of the total consumption. The utility factor is defined as the ratio of kw.-hours generated or sent out per annum to the capacity of plant installed in the power station multiplied by 8,760, *i.e.*, the ratio of average load to installed capacity. The utility factor in the above case would be:—

$$\frac{50{,}000 \text{ kw.} \times .80 \times 8{,}760}{100{,}000 \text{ kw.} \times 8{,}760 \text{ hours.}} = 40 \text{ per cent.}$$

The constant coal losses and running coal consumption in the power stations adjusted to a standard coal value basis of 3.40 kw./lb. are:—

Rosherville	... 100 tons and 2.13 lb./U.S.O.
Vereeniging	... 85 tons and 2.17 lb./U.S.O.
Simmerpan	... 80 tons and 1.93 lb./U.S.O.
Brakpan	... 80 tons and 2.12 lb./U.S.O.

Boiler maintenance is of equal importance to boiler operation in obtaining high efficiencies.

It has been proved by experiment that the gas film offers a resistance of between 95 and 98 per cent. of the total temperature drop from the furnace to the water. It is evident, therefore, that the external cleanliness of the boilers plays a very important part in boiler efficiency, and indeed much more so than a layer of scale of any reasonable thickness on the inside of the tubes.

The usual routine of maintenance is to rough soot each unit once every fortnight or oftener if possible, thoroughly

* Abstract of paper read before the South African Institution of Engineers, by T. G. Otley and Verney Pickles.

soot the unit every 500 hours, to clean the two or three bottom rows of boiler, and all the economiser, tubes internally each 2,000 hours, and to thoroughly clean the whole unit internally and externally every 8,000-12,000 hours.

The steam drums are also opened out and cleaned each 2,000 hours, and the surfaces are rubbed down and painted with tar and graphite.

The practice is to charge everything to maintenance that is carried out on a boiler when it is out of commission, and charge to operation any work in the nature of sooting and lancing, &c., that is carried out when the boiler is either steaming or banked.

The average cost of the operations above mentioned are for a large boiler with integral economiser £48.

Table V gives the totals and weighted average costs of boiler maintenance for all four steam power stations covering 102 boilers installed.

It is only because of the particular attention that is paid to the make-up feed water that the boilers can steam 8,000 to 12,000 hours between thorough internal cleanings.

In order to find the effect of both external and internal dirtiness of a boiler the authors made tests covering long periods on boiler No. 40 at Rosherville, which was fitted with all the necessary instruments, comprising:—

Fery radiation pyrometer,
Three electrical resistance pyrometers,
Steam-flow meter,
Two CO_2 recorders, and
Two draught gauges.

The boiler in question had steamed about 12,000 hours since being last thoroughly cleaned internally. The usual routine programme of sooting and internal cleaning of the bottom rows and the economiser had been carried out. The summarised test results obtained before internal cleaning and after internal cleaning are shown below:—

TABLE VI

	Before.	After.
Date of test	November 7th.	November 21st.
Duration of test ...	12 hours	12 hours
Class of coal burnt ...	Coronation (mixed)	Coronation (mixed)
Energy value	3·46 KW./lb.	3·35 KW./lb.
Total coal burnt ...	68,400 lb.	72,000 lb.
Coal burnt per sq. ft. of grate area per hour ...	22·6 lb.	23·8 lb.
Average evaporation per hour (actual) ...	39,124 lb.	42,576 lb.
Lb. of water per lb. of coal (actual)	6·86 lb.	7·09 lb.
Average steam pressure	216 lb.	218 lb.
Average steam temp. ...	380° C.	349° C.
Average uptake temp. ...	210° C.	191° C.
Average furnace temp.	1,276° C.	1,270° C.
Draught at uptake ...	1·1 in.	1·1 in.
Draught over fires ...	·31 in.	·31 in.
Average CO_2 at uptake	11·3 %	12·5 %
Boiler unit efficiency ...	75·4 %	78·7 %

In each case the boiler had been cleaned externally, so that the difference in the result can only be that resulting from the thorough internal cleaning.

The parts of the chain grate stoker and furnace affecting efficiency are in order of importance:—(1) Ash plates and dumping bars, (2) sealing plates at side of stoker, (3) brickwork of arch, (4) curtain and feed bar.

In the authors' opinion too good a job of the ash plates, ash bearer bars, and dumping bars cannot be made, as unless they are maintained in good condition high efficiency cannot be expected.

In conclusion, the authors remark that it is difficult to see where any great advance in efficiency is to be made; chimney losses could be reduced by using larger economisers, but it is questionable whether it would pay; improved results might be obtained by easier steaming, but would involve more plant. Possibly larger boiler units would slightly increase efficiencies, but the authors look to obtaining larger outputs, not so much by extension of heating surface as by designing boilers to conform more to Osborne Reynold's law, and increasing gas speeds over heating surfaces. This will involve higher draughts, though not necessarily greater coal consumption per sq. ft. of grate.

WAR ITEMS.

The Board of Trade and Enemy Firms.—At the City of London Tradesmen's Club, the President (Mr. Frank Durrant) said he had had a most satisfactory interview with the President of the Board of Trade, in which Sir Albert Stanley assured him that it would be his endeavour to bring his Department into closer touch with the traders of this country. With regard to the enemy businesses, there were obstacles in the way of winding up, but Sir Albert said that no time would be lost, so far as he was concerned, in eliminating the enemy interest. The Department in future would be of real service to the trade of the country.—*Times.*

Trading with the Enemy.—The "London Gazette" for February 16th contains additional lists of firms, &c., in the following countries with whom trading is prohibited, also a number of removals from and variations in previous lists:—Argentine and Uruguay, Brazil, Chile, Colombia, Japan, Netherlands, Norway, Peru, Spain, Sweden, and Venezuela.

Munitions Case.—At Glasgow Munitions Tribunal, an electrical engineer, employed with a steel firm, asked for a clearance certificate in order to go to a situation as foreman armature winder, where he would get £5 a week. His present weekly wage was £2 12s. 6d. The firm's representative held that the appellant was doing work of more national importance in his present employment, but the employer who had offered the man the new situation having given evidence, the Sheriff granted the clearance certificate.

Aluminium Census.—The Ministry of Munitions has issued an Order requiring monthly returns of aluminium stocks to be sent in to the Director of Materials, A.M.2 (H), Hotel Victoria, Northumberland Avenue, London, S.W.

The State and the Coal Mines.—The Board of Trade is taking possession of all the coal mines in the United Kingdom for the period of the war. A new department is being set up, with Mr. Guy Calthrop, general manager of the L. and N.-W. Rly., at the head, which will control the mines and exercise all the powers of the Board regarding coal. Mr. Calthrop will be assisted by Sir R. Redmayne, H.M. Chief Inspector of Mines. According to the *Daily Telegraph*, the main features of the scheme are: (1) To control the coal mines of Great Britain during the war; (2) to organise an executive similar to the executive in the case of the railways; (3) to install machinery for economical handling and distribution; and (4) to pay colliery proprietors their pre-war dividends.

Exemption Applications.—At the Ilfracombe Tribunal, the Ilfracombe Electric Light & Power Co., Ltd., applied for renewal of certificates of exemption for their men, G. Dring, chief man in the station, and T. Saunders, mains and meterman, their original certificates granted by the Recruiting Officer being withdrawn under Army Council Instruction 2,342. Mr. H. J. Stewart, resident engineer and manager, appeared for the company, and stated that the work of these two men was of a highly technical character, many years' experience being necessary; they had tried very hard to find substitutes, but could not do so. These men, one of whom was 41 years of age, were the only two Class A men employed. The Chairman: Have you represented that to the military? Mr. Stewart: Yes; but the military are themselves advertising for similar men in lower classes for their own stations, so are very unlikely to be in a position to provide substitutes. The Tribunal granted temporary exemption to Saunders, and three months in the case of Dring. In the latter case, the Tribunal told Mr. Stewart to appeal again in the event of his being unable to obtain a substitute.

The Military Representative applied to the Fulham Tribunal for the revision of the certificate granted to Mr. S. Allen, an electrical engineer. It was stated that he was still engaged on important work connected with the electrification of the L. & N.-W. Rly. The work required most exceptional skill, and it was utterly impossible to get anyone else to do it. He was an expert, and had carried out similar work when the Metropolitan District Railway was electrified. The Tribunal declined to make any variation.

At Colne Tribunal, on February 16th, the electrical engineer appealed for four employés in the electricity department, two of whom were aged 18, one 19, and another 22. The electrical engineer admitted that he had no instructions to appear on behalf of the Electricity Committee. The Mayor said the youth of 19, who had been passed for C 3, must find work of national importance if called upon. The two of 18 must join the Army on March 17th, and the one of 22 was given three months.

Before the Berks Appeal Court, the Military Representative appealed against exemption until March 30th allowed to E. Slyfield (33), electrician with Mr. Benyon, of Englefield, Bradfield. The appeal was allowed, and the certificate cancelled.

At Uckfield (Sussex), Mr. D. W. Freshfield, J.P., of Wych Cross Place, Chelwood Gate, appealed for the retention of Mr. A. J. Thompson, his electrical engineer. The residence was being utilised as a war hospital. The appeal was respited for consultation with the Red Cross Society.

At Canterbury, on February 12th, Mr. C. A. Blascheck, city electrical engineer, asked for temporary exemption for B. Tapsfield, shift engineer, until he could be replaced. The Military Representative suggested that Tapsfield should be exempted until an efficient substitute was found, and this was agreed to.

Before the Canterbury Tribunal, on February 12th, Mr. Terry, electrical engineer, appealed for three months' exemption for R. Elliot (28), electrical engineer. He is the only man left with Mr. Terry, who desired a short period to enable him to complete contracts, and to replace him. As Elliot is passed for general service, and the appeal was disallowed, but calling-up was deferred until March 12th.

A Ramsgate dealer in electric light fittings, in Class B 1, who had been given conditional exemption, was appealed against by the Military Representative. The certificate was withdrawn, and a final two months' exemption substituted.

At Hull, extended exemption was sought by an electric light and power engineer, aged 33, and in Class B 3. He said that he was engaged to attend to electric motors for various firms. Major Green suggested that applicant should sign an Army Volunteer form, when he would work under the Ministry of Munitions, and would be available to be sent to any place he was required. The Tribunal considered that applicant was at present doing important work, and had better stay where he was. They gave exemption until May 1st.

On the appeal of the Worcester Electric Traction Co., S. R. Davis (30), electric tramway repairer, has been conditionally exempted, subject to substitution.

The Hastings Tribunal has given conditional exemption to Mr. A. J. Ryan, deputy electrical engineer; also to two engine drivers, a meter fixer and fireman, a skilled labourer, a fitter and turner, a junior engineer, two stokers, and a meter and sub-station attendant.

At Chelmsford, Messrs. Christy Bros., electrical engineers, secured exemption, as being in a certified occupation, for N. C. Barnard (38), foreman mechanic and fitter; W. Robinson (40), wireman and fitter; G. W. Balls (39), managing electrical engineer; and C. Parkins (40), pattern maker, &c.

The Surbiton Tribunal has given a fortnight, to enable him to find work of national importance, to an electrician engaged with Sir Ernest Cassel.

At Bath, Messrs. J. Lambert & Sons, electrical engineers, appealed for G. Clark (34), electrical fireman, on the ground that he is engaged on work of national importance. The Tribunal decided that he should get work of national importance in his own trade.

At Stoke-on-Trent, three men engaged at the Corporation electricity works were appealed for by Mr. C. H. Yeaman, borough electrical engineer. He said that they already had five women at one of the works. It was suggested that the men ought to be substituted by older ones, and Mr. Yeaman replied that men over military age had been proved to lack the intelligence to perform certain work. In one case the appeal was disallowed; the other two were each exempted for three months.

The Surrey Appeal Court has allowed an appeal for C. Morgan (29), shift engineer at the Reigate Corporation electricity works.

On the appeal of the Military, the East Kent Appeal Court has disallowed exemption to C. H. Lepper (18), articled pupil with the Folkestone Electricity Supply Co., Ltd.

Exmouth (Devon) Tribunal has conceded conditional exemption to W. H. Dowell (30), assistant in the electrical department of the Red Cross Hospital, who is classified in C 3.

At Dover, on February 14th, Mr. Woodman, borough electrical engineer, applied for exemption, until a substitute could be found, for R. S. Reeves (21), switchboard attendant, who had been debadged. He was passed in Class B 1, and suffered from curvature of the spine. Two months were allowed.

LEGAL.

Hewitson *v.* Newcastle Corporation.

At the Newcastle-upon-Tyne County Court, on 15th inst., his Honour Judge Greenwell gave his reserved judgment in the case, already reported, in which Miss Elsie Hewitson, a local typist, claimed £9 in respect of a suit-case and its contents, being personal luggage of hers, and delivered by her to the defendants, or their servants, to be carried with, and on behalf of, plaintiff while travelling as a passenger on the defendants' tramways, on September 24th, but which, in consequence of the alleged negligence of the defendants, or their servants, was lost. The case was heard on January 19th last.

His Honour, in giving judgment, said there was no substantial dispute about the facts. It appeared that for some years the Corporation had made a charge of one penny for parcels carried by them and placed on the footboard of the cars. Under the circumstances, it was contended by Mr. Mundahl, for the plaintiff, that the Corporation were common carriers, and, as such, were responsible for the loss; and that if not, they had not taken that reasonable care that it was their duty to take. There appeared to his Honour to be no evidence of negligence on the part of the defendants on which they could properly be held liable. He was clearly of opinion that the defendants were the common carriers of their 'passengers' luggage under 28 lb.; and the question arose whether they had, as contended by Mr. Meynell, for the Corporation, succeeded in freeing themselves of liability. Reliance could not be placed upon Sec. 28 of the Local Tramways Act, 1882, because of the charge made, and because of the removal of the luggage from the passengers' control. The defendants relied on the ticket issued in return for the penny. The printing as to the limitation of liability was very small, and he could not read it in the light available in the Court at that moment. As to this point, it seemed to have been settled, more than 40 years ago, by the judgment in Henderson *v.* Stevenson (which his Honour quoted), in which the then Lord Chancellor said there was nothing on the face of the ticket held by the respondent referring him to the back, and there was nothing said by the clerk who issued the ticket directing the respondent's attention to what was printed on the back. "Their Lordships, therefore, may take it as a matter of fact that the respondent was not aware of that which was printed upon the back of the ticket; consequently, so far as any intelligent knowledge of what was there printed is concerned, he cannot be taken intelligently to have agreed to the terms printed on the back of the ticket." His Lordship added that it did not, it seemed to him, depend on any technicality of law, but upon common sense. The Lord Chancellor concluded:—"Can it be held that, when a person is entering into a contract containing terms which, *de facto*, he does not know, and as to which he has received no notice, he ought to inform himself upon them? My Lords, it appears to me to be impossible that that can be held." His Honour held that the facts there, and in the present case, were identically the same, and he, for that reason, said judgment must be for the plaintiff, with costs on scale B.

Bradbear *v.* Balfour, Beatty & Co., Ltd.

In the King's Bench Division, on Friday, Mr. Justice Bailhache and a special jury heard an action for damages for personal injuries brought by a workman against a firm of Government contractors and electrical engineers.

It appeared that the defendants were engaged in the erection of a large military camp in the North of England, and plaintiff was one of the workmen employed. His case was that while going across the grass to the hut where he slept, he collided with an obstruction, breaking his right ankle and leg, and that the defendants were liable for the act of their servants in leaving such obstruction. He was laid up for a considerable time, and he put his loss in wages alone at £90 12s. 6d. There was a permanent injury to his leg, though not of a very serious character. The defendants denied negligence, and pleaded contributory negligence on the part of the plaintiff.

The jury, after a brief deliberation, returned a verdict in favour of the plaintiff for £200 damages.

Judgment was entered accordingly, with costs.

Edmundson's Electricity Corporation, Ltd., *v.* Roscrea (Co. Tipperary) Bacon Factory, Ltd.

In the Irish High Court, Dublin, before Mr. Justice Kenny, plaintiffs sued defendants to recover £43 10s. 10d. for work done and material supplied under contract in connection with the factory, including a number of extras.

His Lordship, who said there was a considerable conflict of evidence in the case, found for the plaintiffs for the whole sum claimed, subject to certain deductions, which brought it down to £41 11s. 3d., and gave judgment for the balance between that amount and an amount lodged in Court. He explained that he based his decision mainly on unanswered letters and the absence of explanations as to accounts on the part of the defendants.

BUSINESS NOTES.

Trade Credit in Russia.—In the course of an article on "The Credit Situation in Siberia," the *Board of Trade Journal* quotes extracts from a report prepared by the Canadian Trade Commissioner at Omsk. In regard to the question of information regarding a customer's standing, it is stated that the success of German firms in the granting of credits in Russia was largely due to the assistance afforded by the home banks. German firms were also greatly helped by the fact that they frequently maintained their own resident agents, who were able to investigate carefully the credit standing of customers. In addition, valuable facilities were afforded by the mercantile agencies, whose ramifications in Russia were extensive. Apart from the assistance to be gained by these means, it is not always an easy matter for foreign firms to obtain information respecting the standing of prospective customers. Banks, as a rule, are only able to supply particulars as to the extent of credit which they consider it safe for them to grant to the party concerned. It is also claimed that the banks are not always in a position to give a disinterested estimate regarding the standing of a client. These considerations, however, apply practically to only a certain class of firms. It is nearly always possible to obtain satisfactory references regarding the standing of responsible and old-established houses.

The Warehouses of Manchester.—A very interesting 48-pp. booklet has just been received from the Port of Manchester Warehouses, Ltd., at Trafford Park. It comes with particular appropriateness just now when everybody is thinking so much about imports and storage accommodation. The company has a closed warehouse capacity exceeding 400,000 tons, the major portion of which has been constructed during the war. There are steel gantries fitted with electric cranes and magnets to stock 100,000 tons of iron and steel. The equipment includes 37 overhead electric travelling cranes, portable electric pilers, elevators and transporters, 300 railway wagons for exchanging traffic with ships in the Manchester Docks, and so on. The half-tone views of the interiors and exteriors of the warehouses, also those of the electric carriers and loaders, cranes, &c., are very effective. The advantages of the warehouses are specially tabulated at the end of the booklet.

Bankruptcy Proceedings.—Brown, F., Llanelly, electrician (formerly partner in Hugh Bros. & Brown).—March 7th is the last day for the receipt of proofs for dividend by Mr. H. W. Thomas, 4, Queen Street, Carmarthen, the trustee.

Catalogues and Lists.—The Edison Swan Electric Co., Ltd., of Ponders End, have issued a wall showcard showing five types of Ediswan batteries in their "natural" colours.

Messrs. Simplex Conduits, Ltd., Garrison Lane, Birmingham.—Leaflet giving illustrations and prices of their inspection lamps for motor vehicle work.

Benjamin Electric, Ltd., 1A, Rosebery Avenue, London, E.C.—Section list No. 509 (16 pages) containing illustrated particulars and prices of their reflector fittings, lanterns, and lighting accessories for industrial and general installations.

Electrical Apparatus Co., Ltd., Vauxhall Works, South Lambeth Road, London, S.W.—The first issue of the "E.A.C. Quarterly Review" contains illustrations and descriptive matter relating to the company's motor-control panels, A.C. drum-type switchgear, automatic control for C.C. motors, house-service meters, and controller regulators for tramcars. The "Review," which opens with the company's Roll of Honour, is intended to form a connecting link between the works and the sales staffs.

Igranic Electric Co., Ltd., 147, Queen Victoria Street, London, E.C.—First part of a new catalogue of "Igranic" electric controlling devices. This consists of a bulky collection of leaflets which is a foretaste of bulkier things to come. It is the firm's aim to make the catalogue in its later form, as newly-issued leaflets appear, the most complete list of electric controlling apparatus ever compiled. The general index foreshadows the ultimate extent and arrangement. Part I will cover direct-current apparatus; Part II, alternating; Part III, controlling devices for lighting circuits (D.C. and A.C.); and Part IV, lifting magnets and magnetic specialities. The information given is descriptive of the manufactures, and tables of sizes, powers, dimensions, prices &c., are given, accompanied by half-tone views and diagrams. It is quite unnecessary for us to give a list of names of manufactures; the ground covered is fairly obvious from what we have already said. Many of the firm's standard types are not included in this first portion of the catalogue, but the trade will probably be aware of the fact that the company can supply control gear for purposes for which no standard patterns exist.

General Electric Co., Ltd., 67, Queen Victoria Street, London, E.C.—Leaflet No. L2,092 gives illustrations and prices of electric bells for use on power circuits. Folder O.S.2,091 gives prices and other particulars of the "Usal" drawn-wire tungsten lamps for pocket lamps, &c.; these folders can be supplied overprinted for the trade.

British Westinghouse Electric and Manufacturing Co., Ltd., Trafford Park.—Circular No. 1,435/2A, of 68 pages, contains a general description of the British Westinghouse Rateau impulse-type steam turbines. In five sections there are dealt with: High-pressure turbines; low-pressure or exhaust turbines; mixed-pressure turbines; back-pressure and reducing turbines; and small turbines. Later in the list, a number of charts are given of official tests, also names of customers and the machines they are using. By means of a map, the distribution of the company's turbines in Great Britain is shown.

Messrs. Berry, Skinner & Co., 86, Newman Street, Oxford Street, London, W.—Illustrated list No. 5,191 (16 pages), in French, giving a description, with prices in the French coinage, code-words, &c., of "Masta" type fuse-switches.

British Thomson-Houston Co., Ltd., 77, Upper Thames Street, London, E.C.—Price list No. 10,502 shows and describes the B.T.H. type of 913 Form "A" hand lamp for workshop and factory use.

Dissolutions and Liquidations.—Railless Electric Traction Co., Ltd.—This company is winding up voluntarily, with Mr. A. Page, 28, King Street, E.C., as liquidator. A meeting of creditors is called for February 26th, at 28, King Street, E.C.

Electric Railway and Tramway Carriage Works, Ltd.—This company is winding up voluntarily, with Mr. L. E. Pickin as liquidator.

G. F. Milnes & Co., Ltd.—This company is winding up voluntarily, with Mr. L. E. Pickin as liquidator.

British Electric Car Co., Ltd.—This company is winding up voluntarily, with Mr. L. E. Pickin as liquidator.

Adams Manufacturing Co., Ltd.—A meeting is called for March 19th, at 8, Bream's Buildings, E.C., to hear an account of the winding up from the liquidators, Mr. L. Hardy and Mr. G. E. Corfield.

R. Organ & Sons, gas fitters and electricians, 88, Winchcombe Street, Cheltenham.—Mr. R. Organ, Sen., has retired from the firm, and the debts, &c., will be attended to by Messrs. R. Organ, Jun., and E. E. S. Organ, who will continue the business under the same name.

Gröndal Kjellin Co., Ltd.—For the purposes of reconstruction, this company is to be wound up voluntarily, with Mr. G. H. Hill, 20, Abchurch Lane, E.C., as liquidator. The new company will be the Gröndal Kjellin Co. (1917), Ltd. Creditors must send in the usual particulars by March 29th.

South Wales Wireless Training College, Ltd.—A meeting is called for March 22nd, to hear an account of the winding-up from the liquidator, Mr. G. F. Willett.

Trade Announcements.—The London address of Messrs. Oliver Arc Lamp, Ltd., is now 46-49, Granville House, Arundel Street, Strand, W.C. Telephone No. unaltered (City 3393).

The Woods-Gilbert (British) Rail Grinding and Milling Co., Ltd., has been formed for the purpose of acquiring from the Woods-Gilbert Rail Planer Co., Ltd., of Melbourne, all the assets, liabilities, and goodwill of the business hitherto carried on by them in Great Britain. They have taken premises at 170, Strand, W.C.

Messrs. Siemens Bros. & Co., Ltd., and Siemens Bros. Dynamo Works, Ltd., have removed their offices from Caxton House, Westminster, to Palace Place Mansions, Kensington Court, London, W. Telegraphic address: "Siemens, Kens, London." Telephone No.: "Western 6349."

The *Hardwareman and Ironmongers' Chronicle* has removed its offices to 265, Strand, London, W.C.

The *Engineering Review* has removed its offices to 13-16, Fisher Street, W.C.

Book Notices.—"*Journal* of the Institution of Electrical Engineers." Vol. LV., No. 263. February, 1917. This issue contains the following papers:—"Principles Involved in Computing the Depreciation of Plant," by Mr. F. Gill and Mr. W. W. Cook; "Post War Electrotechnics," by Dr. C. V. Drysdale; also a tenth list of the names of 81 members on military service.

"Science Abstracts." Sections A and B, Vol. XX, Part 1. January 31st, 1917. Index to Vol. XIX, Sections A and B. London: E. & F. N. Spon. Price 1s. 6d. each net.

"Hydro-Electric Power" (2 vols.) By L. Lyndon. London: Hill Publishing Co. Price, Vol. I, 21s. net; Vol. II, 15s. net.

"Underground Transmission and Distribution," by E. B. Meyer. London: Hill Publishing Co. Price 12s. 6d. net.

Journal of the Röntgen Society. Vol. XIII, No. 50. January, 1917. London; Percy Lund, Humphries & Co., Ltd. Price 4s. net.

"Depreciation and Wasting Assets." By P. D. Leake. London: Sir Isaac Pitman & Sons. Price 10s. 6d. net.

LIGHTING AND POWER NOTES.

Asiatic Turkey.—It is reported that German electrical engineering concerns are looking forward to an important trade in electrical material in Turkey and Asia Minor. One important scheme that is being developed is a plant to utilise certain waterfalls near El Scheab in Syria. It is stated that about 9,000 H.P. will be available, and that the current generated will be utilised for the Damascus-Jerusalem Railway, and for lighting and power purposes in the villages and towns in the district.

Barnes.—Proposed Bulk Supply.—A request having been received from the Ealing T.C. to confer on the question of bulk supply, the chairman of the Council, the chairman of the Electricity Committee, and the electrical engineer were appointed to discuss the matter.

Canada.—On January 1st the Edmonton Power Co. started clearing the ground for the big dam it is proposing to build, 75 miles south-west of Edmonton, on the North Saskatchewan River. It is estimated that the construction of the plant, which will develop 55,000 H.P., will take several years, and cost $5,000,000. In connection with the scheme a contract has been let for the construction of a railway from Edmonton to the dam site.

The British Mining and Smelting Co. is extending its hydro-electric plant at Britannia Beach, Howe Sound, 20 miles north of Vancouver, by the addition of a 2,500-K.V.A. generator coupled to two 1,850-H.P. impulse water wheels, which will operate under a static head of 850 ft., obtained by a diversion of the South Valley River.—*Can. Electrical News.*

Dundalk.—Loan Sanction, &c.—At a meeting of the Urban Council, a letter was read from the L.G.B. for Ireland, in reference to the Council's application for a loan of £5,000 for the extension of the electricity undertaking, and the inquiry held into the matter. The Board stated that it had decided to sanction a loan of £3,000, repayment to be spread over 20 years. It expressed the opinion that the Council had no power, under the Act of 1882, and the Dundalk Electric Light Order, 1897, to borrow the further £2,000 to recoup the Council for repayment of capital or payment of interest on capital or for working capital, and pointed out that it was the clear duty of the Council to provide, for balancing the working account of the undertaking by the addition to local rates of about 10d. in the £ in the estimate for the coming financial year, at the opening of which, it is anticipated, the accumulated deficit will be £1,260.

Harrogate.—Boiler By-Product Recovery Plant.—The borough electrical engineer (Mr. Wilkinson) has been authorised by the T.C., on the recommendation of the Electricity Committee, to prepare specifications, and advertise for tenders, in connection with the erection of steam plant, designed by himself, which embodies the features of smokeless combustion with the recovery of tar and ammoniacal liquors as by-products, the necessary authorisation for construction having been obtained.

London.—Shoreditch.—The Electricity Committee recommends a further advance of 5 per cent. (making 25 per cent. in all) on the schedule charges for electricity for lighting, power and heating, from the date of the March, 1917, meter readings.

Market Drayton.—Street Lighting.—The U.D.C. has agreed to the offer by the Electricity Co. to accept £50 in settlement of its account of £100 for public lighting for the half-year ended December 31st last.

Rochdale.—The Electricity Committee has decided, subject to the consent of the Bolton Electricity Committee, to call in Mr. W. J. H. Wood, borough electrical engineer at Bolton, as consulting engineer for three months, so that he may prepare a report on the present situation, and advise the Committee on the best means of overcoming the difficulty of meeting the demands for electricity. Although the position at the works is improving, the recent frost has prevented the completion of the extension scheme.

Roslea (Co. Fermanagh).—Electric lighting has been installed in the sawmills, clog factory, and scutch mills, the work being carried out by Messrs. McCartney Bros., of Clones.

Salford.—YEAR'S WORKING.—The annual report of Mr. Robertson, borough electrical engineer, shows that 24,856,000 units were sold during 1915-16, as compared with 20,600,000 in the previous year; the increase was mostly accounted for by the increasing power supply, for which purpose 13,650,000 units were supplied, as against 9,900,000 in 1914-15. Both lighting and traction units were also ahead of the previous year, by 12·2 and 2·4 per cent. respectively. The effect on the generating plant is shown by the load factor improving from 26·6 to 30·2 per cent. and by the reduction in total works costs from ·74d. to ·67d. per unit, despite the higher price of fuel, &c. Altogether 29,117,000 units were generated and 1,178,000 purchased; the maximum load was 9,400 KW. and the lighting and power connections totalled 27,726 KW. It is interesting to note that works costs fell from ·56d. to ·50d., and coal costs from ·339d. to ·335d. per unit sold; the cost of the purchased energy (at ·9d. per unit approximately) is distributed over the works costs. During the year a second 5,000-KW. turbo-alternator was installed—a duplicate of the first which was illustrated in our columns in the early days of the war—and a third turbine set of the same size was expected to be in commission for the winter's load. Two Babcock boilers, with economisers, superheaters, and induced draught, have been ordered to supplement the steam plant, and we also note (and draw the E.V. Committee's attention to the fact) that two petrol motor-wagons have been obtained for ash removal and other work. A new agreement has been entered into with the Lancs. Power Co. for bulk supply under more favourable terms; a new sub-station has also been opened and a 3,000-KW. sub-station is being erected. The consumers totalled 3,707 at the close of the year. The financial results, in brief, were a revenue of £134,678, a gross profit of £64,538, and, after meeting interest and loan charges, a net profit of £16,598, of which £8,000 went to rate relief and the balance to the renewals account—the latter fund having a balance of £28,000 in hand. The balance-sheet, apparently, shows that a total of £102,658 depreciation has been written off, and that some £31,000 has been expended on capital account out of revenue.

Sheffield.—YEAR'S WORKING.—The report on the working of the Corporation electricity undertaking for the year to March 31st last is one of the most interesting we have seen. It is, of course, generally known that the Sheffield undertaking has made tremendous strides since the war commenced, and this is borne out by the output sold—77,868,000 units, as against 44,873,000 in 1915, and 26,546,000 in 1914; the whole of the increased output represented power and traction (or low-price units), but the net surplus of £33,296 is the largest yet recorded (roughly 51 million power and 20 million traction units were sold). The total units generated amounted to 90½ millions, and we note that 131,000 tons of coal were consumed. The generating plant capacity was 42,225 KW., and the maximum demand was 31,706 K.V.A., while the total KW. connected was 83,834, which included 69,074 H.P. of motors.

We note that at the time of the report 28,000 KW. of additional generating plant was being added, and that 18,000 KW. of additional load was awaiting connection, and since that time, as our readers will have gathered, it has been decided to provide another large generating station on a new site.

The capital cost per KW. on electric supply plant had fallen in 1916 to £41 per KW.

The disproportionate increase in the cost of fuel resulted in a small increase in the total costs per unit, from ·41d. to ·44d., fuel cost having risen from ·19d. to ·27d. per unit, the costs being those of the Sheaf Street, Neepsend, and Kelham stations combined. The average price per unit sold was ·85d., power supply averaging ·71d. per unit.

The total revenue was £314,437; gross profit, £133,409; and surplus, after meeting interest and loan charges, £33,296, which, with accrued interest, left £40,278 for appropriation. Of this sum, £39,778 was devoted to renewals, and £500 to the hire-motor fund.

The renewals fund has a balance in hand of £53,000, and the reserve fund, of £10,000, but the total appropriation for renewals and reserve to date amounts to £109,000. In passing, we congratulate the Electricity Committee and its engineer, Mr. Fedden, on the policy which has been adopted of keeping the surpluses in the undertaking; charity, in the form of rate aid, at the expense of a municipal undertaking which has to replace its contribution with borrowod money at a high rate of interest, and necessarily passes the added cost on to the consumer, to the detriment of local trade and industry, is an empty gift in any case.

Southend-on-Sea.—PROPOSED EXTENSIONS.—The Electric Lighting Committee has considered the extension of the generating plant in order to cope with the increasing demand for current, and has decided (subject to the usual sanction) that application may be made to the L.G.B. for leave to borrow £45,520 for the provision of additional generating plant at the electricity works. An application was received from the Southend Gas Co. for a supply of current for power purposes at the gasworks.

Stratford-on-Avon.—The T.C. has decided to continue the agreement under which the Electricity Co. can charge a higher rate per unit for current, for another year.

Swinton and Pendlebury.—The Lancashire Electric Power Co. has notified the Council that it will be necessary to increase the charge for electricity by ·2d. per unit, owing to the increased cost of fuel.

Torquay.—SUPPLY DATA.—During the 12 months ended December 31st, 1916, 1,286,460 alternating-current units were generated, as against 1,208,258 units in the previous year. As regards direct-current units, the figures were 1,166,460, as against 1,080,860. The public lighting decrease was equivalent to 78·2 per cent. The units sold to the Tramway Co. showed an increase for the year of 4·22 per cent.

Troon.—The town clerk reported to the T.C. that he had communicated the Council's decision to the engineer regarding the proposal to use overhead cable to supply a hosiery factory. It was recommended that the attention of the B. of T. be drawn to the use of overhead cable without the consent of the local authority, and in violation of its wishes.

Whitstable.—The U.D.C. has decided to give the Electricity Co. seven days in which to take such proceedings as will define the legal position between the Receiver and itself; otherwise, the Council will feel bound to take such steps as may be necessary to protect itself from further liability.

TRAMWAY and RAILWAY NOTES.

Blackburn.—ACCIDENTS.—On Sunday last a collision occurred between two cars, one following the other, in a thick fog, one driver being injured; on Thursday, last week, a collision occurred between two cars travelling in opposite directions at Oswaldtwistle, due to the slippery rails, and two passengers and a driver were injured.

Bolivia.—Railway construction in Bolivia is in a backward state owing to the difficulties of the country; as a consequence, attention is mainly directed to the conversion to electric traction of such lines as are already in existence. Where new lines are projected, only those suitable for electrification are favoured. In either case, Bolivia presents an opening of some value to over-sea electric industries. Among new schemes at the moment is the electric railway from Isa Paz to Yungas, officially sanctioned in 1915. The estimated cost of the line is 12,000,000 fr., met by the issue of departmental bonds guaranteed by the Government; the Board of Public Works is carrying out the construction.—*La Revue Générale de l'Electricité.*

Canada.—According to the *Canadian Engineer*, the Mount Royal tunnel of the Canadian Northern Railway is now practically completed, and permanent track is being laid; it is expected that trains will be running into Montreal by next June. Two 80-ton electric locomotives are now in use, and four more will be purchased for the regular service.

Lancashire.—WAR BONUS.—Following upon the exclusion by the Committee of Production of females from the war bonus granted to tramway workers recently, an effort is being made to secure the concession for them. The general secretary of the Tramway Workers' Association has sent to all the Corporations and companies included in the previous arbitration an application for a bonus of 6s. 6d. per week, less any war bonus granted since the outbreak of the war to male workers. The girls employed on Bolton tramways are included in the application, though it is understood that they are not members of the Association.

Both the permanent-way men and the females employed as conductors on the Preston Corporation Tramways have applied for the war bonus of 6s. 6d. per week recently awarded to certain tramway employés by the Committee on Production, but the Tramways Committee states that it is not able to depart from the terms of the award.

London.—L.C.C.—The Highways Committee reports that the additional financial burdens placed upon the Council's tramway undertaking from the outbreak of the war to March 31st, 1917, in respect of wages, &c., to employés are as follows:—War bonus and war wages, £172,150; increases in rates of pay, £8,300; war service allowance, £250,950; a total of £431,400.

On the basis of the present establishment, the additional annual cost under these three heads is £268,400, which is equivalent to a charge of 1·288d. per car-mile run. The cost of the salaries and wages in the tramway department increased from 4·70d. per car-mile in 1911 to 5·60d. per car-mile in 1915-16.

The Highways Committee has submitted a scheme for the reorganisation of the Council's tramway department. It is proposed to divide the work into five branches—traffic, electrical, rolling stock, permanent way, and general; the position of deputy chief officer is to be done away with, the heads of branches to be directly under the chief officer.

The traffic branch is to be subdivided into two sections—a development and publicity section, and an operation section.

The Committee points out that the Council's tramways have to compete for traffic with other means of transit, and the develop-

ment of the undertaking on successful lines must, to a considerable extent, depend on constant and well-directed effort to adjust the services to public need.

Equal importance is also attached to publicity work; the chief officer is of opinion that an expenditure of from £15,000 to £20,000 would be necessary to advertise adequately the Council's tramways. The Committee considers that greater use should be made of the Press to convey to the public the advantages peculiar to the tramway service.

Under the reorganisation scheme, the Committee recommends the following appointments:—Traffic manager at a salary of £1,200, rising to £1,500 a year; the position of electrical assistant to be abolished and an electrical engineer appointed at £1,200, rising to £1,500 a year; a rolling stock engineer, £1,000 to £1,200, the position not to be filled at present; permanent-way engineer, £800 to £1,000; a chief clerk, and in the traffic branch a development superintendent, at £500, rising to £700; an operation superintendent, £500 to £700; and a publicity assistant at £300 to £400. Minor appointments and rearrangements of certain offices are also recommended for the position of electrical engineer, development superintendent, and operation superintendent; it is proposed to arrange for advertisements to be issued.

At its meeting, on Tuesday, the Council approved the above scheme of reorganisation; Mr. J. K. Bruce (deputy chief officer) was appointed traffic manager at £1,250 per annum. It was mentioned that Mr. A. L. C. Fell, chief officer, had returned to duty after six months' absence on sick leave.

Southend-on-Sea.—Owing to the difficulty of obtaining male drivers, inquiries are being made to ascertain from other towns, which have engaged women drivers, their experience of the adoption of this experiment. Arrangements are to be made for the conversion of one of the large bogey cars into a double-decked car, as an experiment, at an approximate cost of £75.

CONTRACTS OPEN and CLOSED.

OPEN.

Aberdare.—March 7th. Powell-Duffryn Steam Coal Co. Electrical goods for 12 months. Stores Manager, Aberaman Offices, Aberdare.

March 8th. U.D.C. Annual tenders for cable, meters, joint boxes, electric lamps, &c., for the Electricity and Tramways Department. See "Official Notices" to-day.

Australia.—Sydney.—March 5th. Council. One 7,500-k.v.a. turbo-alternator. See "Official Notices" January 5th.

Adelaide.—March 28th. P.M.G.'s Department. Telephones, telephone parts, line and battery material, &c. Schedules 444 to 453. See "Official Notices" February 2nd.

Melbourne.—March 7th. Council. 1,048 electricity recording meters. See "Official Notices" February 9th.

March 21st. Victorian Railways. 200 half-watt lamps and 100 lanterns; also 100 contact couplings.* April 4th. Terminal blocks (complete) for electrical connections.

Brisbane.—February 28th. P.M.G.'s Department. Telephone apparatus, Schedule 385; car-pieces, &c., Schedule 386; heat coils, protectors, &c., Schedule 391. See "Official Notices" to-day.

March 28th. P.M.G.'s Department. Cable (switchboard), Schedule 394.

Argentina.—Buenos Aires.—March 30th. Electric carbons during 1917, for the municipality. Local representation. Conditions from Oficina de Licitaciones, Intendencia Municipal de la Capital, Avenida de Mayo 525, Buenos Aires.—*B. of T. Journal.*

Barrow.—March 5th. Corporation. Electrical stores for 12 months. Borough Electrical Engineer.

Bedwas (Mon.).—March 8th. Bedwas Navigation Colliery Co., Ltd. Twelve months' supply of electrical goods, &c. Mr. G. Morgan, Secretary.

Belfast.—March 3rd. Electricity and Tramways Committee. Tramway stores, including electrical accessories, cables, lamps, &c. See "Official Notices" to-day.

March 14th. Electricity and Tramways Committee. Six or twelve months' supply of stores, including several electrical items, for the Electricity Department. See "Official Notices" to-day.

Bolton.—March 7th. Electricity Committee. Materials and stores. See "Official Notices" February 16th.

Brighton.—March 9th. T.C. Five-ton steam motor-wagon and 3½-ton electric motor-wagon. Particulars from Mr. H. Talbot, Town Clerk.

Canada.—March 28th. Toronto Electric Commissioners. Synchronous condensers, 5,000, 7,500 or 10,000 k.v.a. capacity. See "Official Notices" February 9th.

Glasgow.—The general manager of the Corporation Tramways Department is to obtain offers for the supply of an electrically-propelled vehicle for the use of the department.

Grenada.—March 31st. The time for tendering for the Government electric light and power concession, already announced, has been extended to March 31st.

Harrogate.—March 5th. Corporation. By-product steam boiler plant. See "Official Notices" February 2nd.

Kilmallock.—March 5th. Kilmallock (Co. Limerick) E.L. & P. Co., Ltd. Hydraulic turbine, dynamo and motor booster, battery and switchboard. See "Official Notices" February 16th.

London.—Hammersmith.—February 28th. B.C. Electricity stores for 12 months. See "Official Notices" February 16th.

Metropolitan Water Board.—March 8th. Twelve months' supply of electric lamps. Chief Engineer, Savoy Court, Strand, W.C.

L.C.C.—The Highways Committee recommends that tenders be invited for alterations to the switchboard gallery and for the laying of additional condenser water pipes at the Greenwich generating station.

Londonderry.—March 17th. Corporation. Engine-room stores, carbons, electricity meters, cables, &c., for the Electricity Department. Town Clerk.

Macclesfield.—March 14th. Cheshire County Asylum. Electrical goods for one year. Mr. W. G. F. Tingay, Clerk to the Asylum, Parkside.

Manchester.—March 7th. Electricity Committee. Coal-conveying plant and suction ash plant. See "Official Notices" February 9th.

March 14th. Corporation. Nine 40-h.p., three-phase, slip-ring motors. See "Official Notices" to-day.

Stockton-on-Tees.—March 12th. Stores for the T.C. Electricity Department. See "Official Notices" to-day.

Specifications for the items marked * can be seen at the Board of Trade Commercial Intelligence Department in London.

CLOSED.

Bedford.—The Education Committee has accepted the tender of Mr. F. Nash for electrical work until June 30th.

The T.C. has accepted the following tenders:—

Siemens Bros. & Co., Ltd.—Cables, £3,273, and laying and jointing, £2,631.
British Electric Transformer Co., Ltd.—Six transformers, £1,136.
Stirling Boiler Co., Ltd.—Two boilers and mechanical stokers, £6,610.
British Thomson-Houston Co., Ltd.—Turbo-generator and condensing plant, £8,674.

Government Contracts.—List of new contracts placed during January, 1917:—

War Office.

Electric cable and wire.—B.I. & Helsby Cables, Ltd.; Callender's Cable and Construction Co., Ltd.; Craigpark Electric Cable Co., Ltd.; Fuller's Wire & Cable Co., Ltd.; W. Geipel & Co.; General Electric Co.; W. T. Glover & Co., Ltd.; A. Green, Ltd.; Hooper's Telegraph and India-Rubber Works, Ltd.; Liverpool Electric Cable Co., Ltd.; Midland Electric Wire Co., Ltd.; St. Helens Cable & Rubber Co., Ltd.; Siemens Bros. & Co., Ltd.; I.R., G.P. & Telegraph Works Co., Ltd.
Electric cells.—Siemens Bros. & Co., Ltd.
Ebonite rod and sheet.—I.R., G.P. & Telegraph Works Co., Ltd.; Peel-Conner Telephone Works, Ltd.
Electric lighting sets.—Aster Engineering Co., Ltd.
Generating sets.—Austin Motor Co. (1914), Ltd.; Coventry Simplex Engines, Ltd.; W. H. Dorman & Co., Ltd.; Heatley-Gresham Engineering Co. Ltd.; A. Lyon & Wrench, Ltd.; Record Engineering Co., Ltd.
Generating plant.—Austin Motor Co., Ltd.
Wood telegraph-poles.—Davey & Armitage.
Switchboards.—Dorman & Smith.
Iron and steel wire.—Dorman, Long & Co.; R. Johnson & Nephew, Ltd.; Rylands Bros., Ltd.; Shropshire Iron Co., Ltd.; Whitecross Co., Ltd.

India Office Store Department.

Accumulators.—Pritchett & Gold, &c., Co.
Crucibles.—Morgan Crucible Co.; J. C. Waterhouse, Ltd.
Telephones.—Siemens Bros. & Co.; Peel-Conner Telephone Works.

H.M. Office of Works.

Engineering works.—Electric wiring, Admiralty Transport Building: Alpha Manufacturing Co.

Post Office.

Protective apparatus.—British L. M. Ericsson Mfg. Co., Ltd.
Telegraph apparatus.—Creed & Co., Ltd.
Telephone apparatus.—British L. M. Ericsson Mfg. Co., Ltd.
Telegraph cable.—Craigpark Electric Cable Co., Ltd.; Siemens Bros. and Co., Ltd.
Telephone cable.—W. Geipel & Co.; W. T. Henley's Telegraph Works Co., Ltd.; Siemens Bros. & Co., Ltd.; Union Cable Co., Ltd.; Western Electric Co., Ltd.
Cable drums.—B.I. & Helsby Cables, Ltd.; Western Electric Co., Ltd.
Flameproof wire.—London Electric Wire Co. & Smiths, Ltd.; C. Macintosh and Co., Ltd.
Plates for stay-rods.—Walls, Ltd.
Iron poles.—Siemens Bros. & Co., Ltd.
Ironwork, steel poles and fittings.—Bullers, Ltd.
Galvanised-iron wire.—Dorman, Long & Co., Ltd.; R. Johnson & Nephew, Ltd.; Rylands Bros., Ltd.; F. Smith & Co., Wire Manufacturers, Ltd.; Whitecross Co., Ltd.
Vulcanised I.R. wire.—Union Cable Co., Ltd.

Weymouth.—T.C. Accepted tender:—

Johnson & Phillips, Ltd.—Booster and switchgear, £980; cables and laying, £5,520.

FORTHCOMING EVENTS.

Junior Institution of Engineers, London.—Friday, February 23rd. At 7.30 p.m. "Random Notes on Structural Design," by Mr. C. G. D. Burdett. Friday, March 2nd. At 7.30 p.m. "Tool-Store Management," by Mr. S. A. Roberts.

Association of Supervising Electricians.—Tuesday, February 27th. At 7.15 p.m. At St. Bride's Institute, Bride Lane, E.C. Paper on "Modern Power Cables," by Mr. H. Savage.

Institution of Electrical Engineers (Manchester Local Section).—Tuesday, February 27th. At 7 p.m. At the Engineers' Club. Paper on "Some Points in connection with Engineering Specifications," by Mr. J. Shepherd.

Royal Institution of Great Britain.—Tuesday, February 27th. At 3 p.m. At Albemarle Street, Piccadilly, W. Lecture on "The Strength and Structure of Metals," by Prof. W. E. Dalby, F.R.S.

Chemical Society.—Thursday, March 1st. At 8 p.m. At Burlington House, Piccadilly, W. Ordinary scientific meeting.

SUBSTITUTION IN ELECTRICITY WORKS.

Mr. H. Faraday Proctor, honorary secretary of the Incorporated Municipal Electrical Association, has, by request of the Reserved Occupations Committee (St. Ermin's Hotel), fowarded to members a copy of a letter and memorandum addressed to the Association by the Committee, under date February 5th. The Committee draws attention to the revised list of certified occupations which came into force on February 1st, and adds:—"You will see that the reservation for electrical generating stations remains unchanged for the present, and that no age limit has been imposed. This exceptionally favourable treatment cannot, however, be continued without modification, and the enclosed memorandum has accordingly been prepared for the guidance of electrical undertakings in effecting substitution and thus releasing men for the Army."

Mr. Faraday Proctor, in forwarding the memorandum, which we print below, to members, makes the following observations:—

"The Committee particularly desire that all electrical undertakers should take action in this matter as speedily as possible, and that disabled soldiers and sailors should be used as far as possible at electric generating stations, but that if a sufficiency of such disabled men is not forthcoming, there may be no delay in introducing women for occupations where their services are capable of being used.

"You will probably be aware of what is being done in the matter of training disabled soldiers and sailors at the Northampton Institute and elsewhere, in which matter the Institution of Electrical Engineers is taking a prominent part.

"The question of data as to the sufficiency of men for the various positions, as also the question of technical advice in the matter of retaining a sufficiency of skilled operators in electricity works, is receiving attention at the present time."

[*Copy of Memorandum issued by the Reserved Occupations Committee for the Guidance of Electrical Undertakings in effecting substitution of and releasing Men for the Army.*]

ELECTRICAL GENERATING STATIONS.

It is known that many electrical generating stations have lost a considerable number of men through enlistment, while, at the same time, especially in towns with a large number of munition works, the demands for current are much greater than ever. In small towns, staffs in normal times are often so small as to leave but little margin for reduction. Moreover, many of the occupations inside the stations, and some of those outside, in connection with the mains and with installation, require skilled engineers, mechanics, or trained workers of long experience.

It is for these reasons that the reservation for electrical generating stations in the List of Certified Occupations has hitherto been so wide, all classes of workmen being covered, and no age limit imposed. It is felt, however, that this exceptionally favourable reservation cannot be continued without modification after the end of February, and managers of electrical undertakings should make every effort to release men for the Army by substituting women, disabled men, or men of inferior medical categories for men of military age and fitness. The following memorandum has been prepared with a view to assisting managers in this purpose:—

I.—Substitution by Disabled Soldiers or by Men of Inferior Medical Categories.

It is suggested that inexperienced unskilled men would be suitable for immediate employment, without training, in some of the jobs in an electrical station. Nevertheless, disabled soldiers could be utilised in some occupations, *e.g.*, as assistant switchboard attendants, with a moderate amount of training, or even, in some of the smaller stations as switchboard attendants to release men of military age and fitness.

In the same way, men of inferior medical categories can often perform efficiently work upon which men of Category A or B 1 are are at present employed, thus releasing the latter. Under certain conditions the Army Council are even prepared to exchange trained men of the lower medical categories who have already joined the Colours for men of Category A or B 1, returning them *to their former employers*, where their services are likely to be of greater service than elsewhere, and where they can live at their own homes. Firms desirous of taking advantage of this arrangement should communicate with the Secretary (D.R. 4), War Office Annexe, Whitehall Place, London, S.W.

II.—Substitution by Women.

Substitution of women for men is possible for some jobs, and has already been successfully started in certain stations in the processes indicated below. In connection with one large station 21 women are now employed.

Switchboard Attendants and Attendants at Sub-Stations.

This applies both in the main generating stations and in those larger sub-stations which require the constant presence of such workers. For these posts a superior type of woman should be engaged if available, preferably one who has had some scientific training. In large stations where two or three attendants, or more, are engaged on each shift, it would doubtless be necessary to have, as charge hand on each shift, a skilled male attendant; but junior switchboard attendants can readily be replaced by suitable women. Normally junior switchboard attendants are youths who undertake such work for a time, in order to gain practical switchboard experience, as a stepping-stone to the position of electrical engineer.

In some of the less important sub-stations women can also be employed; but in those which ordinarily require the presence of one man only it is recommended that two women should be substituted, when these have been trained, in view of the possibility that a woman working alone may, in case of emergency, lose her presence of mind. The work of sub-station attendants being eminently suitable for disabled soldiers and sailors, provided they are carefully selected, it is desirable that they should be obtained where possible for training and employment in preference to women.

Meter Testing.—This work also would call for women of a superior type, and although it would require a long preliminary training before they could undertake it unaided, women could perform useful work as assistants whilst being trained. Other jobs which ordinary working women can successfully undertake are:—

Cleaning of Station and Machinery.—In the modern stations, fitted with high-speed turbo-generators, cleaning operations are much simpler and can be done with but little risk of accident, compared with the older stations, where the machinery is not enclosed, and the various parts which require cleaning are difficult to get at. Even in the latter case, cleaning of machinery—*e.g.*, engines and dynamos, *whilst at rest*—can very well be done by women, if suitably clothed and if proper appliances—*e.g.*, step ladders, movable wood platforms, &c.—are provided to give safe access to the various parts. For such work as cleaning floors, &c., women are of course very suitable.

Labourers in Boiler Houses and Refuse Destructors.—There is not much scope for women in the modern type of boiler house, where the coal and ash handling and stoking is done mechanically, but in the smaller stations they can be employed in such jobs as ash wheeling and cleaning up. Much can be done in this and in other occupations, to facilitate the employment of women by providing smaller barrows, suitable overalls or other clothing, and the like.

Meter Reading.—This outdoor work can well be done by women.

General.—In all cases where women or girls are employed separate sanitary and washing conveniences should of course be provided, and provision should, if possible, be made for the supply of meals apart from the men.

In certain shift work a modification of the Factory Acts would be required to permit of the employment of women at night and on Sundays; but the Home Office are at all times ready to consider applications for permits for the employment of women in this manner, under suitable safeguards.

NOTES.

Electrically-Welded Tool Tips.—An article in a recent issue of the *Railway Review* refers to the practice of the Westinghouse Electric and Manufacturing Co., of East Pittsburg, which is at the present time utilising the electric arc process for welding high-speed steel tips to machine-steel shanks for cutting tools for many of its planers and lathes. Old, worn-out high-speed steel tools can be cut to proper size and utilised for tips, with resulting economy in costly material.

The arc welding process has been found much cheaper than the oxy-acetylene and forging methods. For best results, a current of 100 amperes at 60 to 70 volts is employed, using a $\frac{5}{32}$ in. Norway iron electrode. A good operator will make 25 to 30 welds of 1½ sq. in. cross-section tools in 9½ hours.

Electric Light Switching.—The following is the result of Messrs. Lundberg's Third Batch Exam. (names in order of merit):—

Advanced Grade.—John Moran (Bury, Lancs.), E. Emery (Old Hill, Staffs.), C. R. Gunn (Liverpool).

Intermediate Grade.—R. G. Stripp (London, N.W.), H. S. Edwin (Dartford), J. Hamer (Dewsbury), J. T. Watkin (Newark), F. Townshend (Cape Town, S.A.) *Another paper:* R. P. Gilbert (London, N.). *Another paper:* Sapper A. J. Tourle, R.E. (Dunstable).

Preliminary Grade.—Reginald A. Paxton (Manchester), R. F. Nailor (London, W.), G. D. Hamavala (Bombay), E. Briggs (Barnsley), R. Ellis (Port Talbot), "Spark" (Paisley), C. McLindon (Delgany, Co. Wicklow). *Another paper:* F. White (Grantham), J. Hesson (Workington, Cumberland), A. Collins (Eastbourne), A. Pizzuto (Malta), Pioneer V. T. Rawlins (B.E.F.), W. P. Stockdale (Leadgate, Co. Durham). *Another paper:* C. H. Dutton (London, W.), H. Parkinson (Stoke-on-Trent).

Candidates whose names do not appear above, and who have not received intimation of failure, are informed that their papers will be included in the next batch. Full particulars regarding these periodical Exams. may be had on application to Messrs. A. P. Lundberg & Sons, 477-489, Liverpool Road, London, N.

Institution and Lecture Notes.—Institution of Engineers and Shipbuilders in Scotland.—On Tuesday, two papers were down for reading at Glasgow: "Economic Recuperation After the War," by Prof. W. R. Scott; "Influence of Retarders on the Transmission of Heat Through Boiler Tubes," by Mr. R. Royds.

Institution of Gas Engineers.—The annual meeting will take place in London, on Tuesday, June 5th. There will be a presidential address, but no papers. On June 6th, there will be a visit to the works of the Tottenham District Light, Heat and Power Co., to view the new section of the works now approaching completion. The company's electric generating station at Wood Green will also be inspected.

Institution of Mechanical Engineers.—The report of the Council for 1916 shows a total membership of 6,247, a reduction of 72 during the year. The total revenue was £22,444 and the expenditure £12,629, leaving a surplus of £9,815. The total investments and other assets amounted to £137,588, and the net capital to £75,692. Over 900 members were on active service during the year. A sum of £500 has been granted in aid of the translation of the specifications of the British Engineering Standards Committee into French, Spanish, and Russian, with metric equivalents of English measures, and to enable them to be sold at lower prices, the Council regarding this work as of vital importance to British engineering firms.

Institution of Electrical Engineers.—Mr. Joseph Taylor, hon. secretary of the Scottish Local Section, intimates that the next Edinburgh meeting will be held on March 20th, when Mr. S. A. Juhlin will read a paper on "Voltage Regulation of Rotary Converters."

Dr. Alex. Russell delivered his Kelvin lecture—"Some Aspects of Lord Kelvin's Life and Work"—at the monthly meeting of the Scottish Local Section, in Glasgow, on February 16th. He gave some interesting reminiscences of his own boyhood and youth in Glasgow, and recalled the names and characteristics of several of his teachers and professors at Glasgow University. After the lecture—which has already been abstracted in our pages—Dr. Russell, in proposing a vote of thanks to Prof. Gray for the assistance given him in providing apparatus for the experiments in connection with the lecture, said that Prof. Gray had been an able successor to Lord Kelvin, and his work was well known to experts all the world over. Early in the proceedings, the chairman (Mr. J. K. Stothert) announced the following nominations by the Committee for the office bearers for the session 1917-18:—Chairman: Mr. Archibald Page; vice-chairmen: Messrs. E. T. Goslin and A. S. Hampton; hon. secretary: Mr. Joseph Taylor; assistant hon. secretary: Mr. Wm. F. Mitchell; Committee: Messrs. F. H. Whysall, W. W. Lackie, and W. B. Hird, Prof. Maclean, Messrs. Alexander Lindsay, A. S. McWhirter, D. M. Macleod, Archibald Wilson, J. E. Sayers, Sam Mavor, and J. F. Neilson. The three last named are new members, the others being already in office.

The next ordinary general meeting of the Students' Section will be held at the City and Guilds' Technical College, Finsbury, on Wednesday, February 28th, at 7.45 p.m., when Mr. R. P. Howgrave-Graham will read a paper on "Some Experiments with High Voltages." Dr. C. V. Drysdale will preside. The paper should prove interesting and educational, it being almost entirely experimental.

At a meeting of the Newcastle Local Section on February 12th, a discussion on the decimal system of coinage and weights and measures was introduced by Mr. Gerald Stoney, who urged the adoption of such a system as an imperative necessity. Several speakers took part in the discussion, almost without exception supporting the proposal. At the same meeting the chairman, Mr. H. W. Clothier, said the Committee had received from London proposals in regard to arranging a local scheme for the training of disabled sailors and soldiers. The Committee had made fairly full inquiries, and found that already there had been a good deal of progress made in the Newcastle district. Classes were being held in connection with a local power company, and the Cowen Training Home had already organised a class for training men, more particularly with the object of making them fit to take charge of the running of private installations, &c. The present accommodation at the Cowen Home was greater than the demand.

On February 16th, under the auspices of the Dublin Local Section Mr. L. J. Kettle delivered a lecture on the Dublin Electricity Works, in the course of which he drew attention to the existence of the Rathmines and Pembroke electricity works, as well as the tramway power station, in close proximity to the city, and argued that the two first-named could be economically supplied from the Dublin works without increasing the plant installed there, and that the saving in cost of supply would probably amount to some £6,000 a year.

Correspondence.—We have received the following letter:—

"With reference to the action between the Rugby Urban Council and myself, reported in your issue of the 2nd inst., I notice the report has been worded as if I had pleaded guilty to the whole of the Council's *suspicions*, whereas I pleaded guilty only to the technical charge of using current from the power mains for lighting. Also no mention is made of the extenuating circumstances—viz., that the meter was registering 33 per cent. too high, as admitted by the prosecution, and that I was paying a flat rate of 2d. per unit, no current being used for power purposes.

"With reference to the three terminals in the hall, the report reads as if the meter had been actually short-circuited, whereas these connections were never made, and witness for the prosecution admitted that they had no evidence that this had been done, the terminals having been used for quite another purpose.

"With reference to the 300-c.p. lamp mentioned in the report, this was only the size estimated by the Council's official, the real size being 150 c.p., and the lamp having never been used for lighting.

"The above corrections to the report will oblige.

"Rugby, *February 20th*, 1917." "H. L. Smith.

Imperial Preference.—The resolutions which were adopted by Lord Balfour of Burleigh's Committee have been issued as a White Paper. They are stated in this form in view of the approaching Imperial Conference:—

"1. In the light of experience gained during the war, we consider that special steps must be taken to stimulate the production of foodstuffs, raw materials, and manufactured articles within the Empire wherever the expansion of production is possible and economically desirable for the safety and welfare of the Empire as a whole.

"2. We therefore recommend that His Majesty's Government should now declare their adherence to the principle that preference should be accorded to the products and manufactures of the British Overseas Dominions in respect of any Customs duties now or hereafter to be imposed on imports into the United Kingdom.

"3. Further, it will, in our opinion, be necessary to take into early consideration, as one of the methods of achieving the above objects, the desirability of establishing a wider range of Customs duties which would be remitted or reduced on the products and manufactures of the Empire, and which would form the basis of commercial treaties with Allied and Neutral Powers."

The Berne correspondent of the *Morning Post* quotes the *Vorwärts*' remarks in regard to the report of the Balfour Commission proposing preferential tariffs for the British Empire. The *Vorwärts* observes that preferential duties for the British Dominions will hit Germany's export trade "as they are intended to do," and concludes with the mournful reflection that "the British world Empire was our best customer; it bought one-fifth of our exports."

Appointment Vacant.—Shift engineer (42s.), for the Queen Mary's Military Hospital (County Asylum), Whalley. For particulars see "Official Notices" to-day.

National Service. — The Important Trades. — The Director-General of National Service has issued, for the guidance of volunteers, a detailed list of trades and occupations of primary importance for which men are urgently required. In the "Shipbuilding and Engineering, including Repairing," Section, special mention is made of electrical engineering, the manufacture of internal combustion engines, and "other engineering works engaged in repairing machinery or plant for use in industry." In the "Miscellaneous Metal Trades" mention is made of electrical accumulator manufacture and repairing, scientific instrument making, and steel and copper wire-drawing. The "Public Utility Services" named include electrical generating stations and tramways (in connection with munition works).

Fatalities.—An inquest was held at Newcastle-on-Tyne, on Tuesday, respecting the death of an electrician named James Fairen, employed by Messrs. Armstrong, Whitworth & Co., Ltd., at Scotswood. Bert Clements, a work-mate, stated that they were repairing an electric crane on Saturday night. Fairen was lying stretched out on a plank 9 ft. long by 7 in. wide and 1½ in. thick. It was inclined at a steep angle between the higher and lower girders of the crane. When his back was turned witness heard a shout, "Bert, I'm falling," and he saw deceased fall to the ground, a distance of 49 ft. The jury returned a verdict of "Accidental death," and it was stated that the firm had now arranged with H.M. Factory Inspector to alter the method of cleaning the electric cranes.

George Scott (59), chargeman at the Mexboro' electric power station, was found last week, lying dead at his work, bleeding slightly from the nose. He had suffered from bronchial trouble for several years, but had left home in apparently his normal health. Death was declared to be due to heart failure, following bronchitis. An inquest was not considered necessary.

According to the *Times*, Alfred Harrison, a labourer at the Derby Corporation electricity works, was fatally scalded on Wednesday by the bursting of a tube.

British Industries Fair.—This Fair opens on Monday next, February 26th, at the Victoria and Albert Museum and the Imperial Institute, and will remain open until March 9th.

Parliamentary.—The Lancashire Power Construction Co. is applying for an Act to re-arrange, convert, increase and reduce the capital, and to confer other powers.

Magneto Manufacturers' Association.—A recent issue of the *Motor* announces the formation of the British Ignition Apparatus Association, which embodies practically all the magneto manufacturers in the country. At the present time over a dozen British firms are making magnetos, and their output to date reaches 165,000 magnetos for war purposes.

Damaging Insulators.—At Thorne Police Court, near Doncaster, last week, two youths were fined £1 10s. each for damaging telegraphs by shooting at the insulators with catapults. The police stated that during last year over 100 insulators were broken on that particular part of the line, and this year, up to the present, 56 had been broken. It was a very serious matter, particularly at the present time, for telegraph lines to be damaged.

Volunteer Notes.—First London Engineer Volunteers.—Headquarters: Balderton Street, Oxford Street, W.—Orders for the week, by Lieut.-Col. C. B. Clay, V.D., Commanding :—

Monday, February 26th.—Technical for Platoon No. 9, at Regency Street. Squad and Platoon Drill, Platoon No. 10. Signalling Class. Recruits' Drill. 6.30—8.

Wednesday, February 28th.—Instructional Class, 6.15. Platoon Drill, Platoon No. 2.

Thursday, March 1st.—Platoon Drill, Platoon Nos. 5 and 6. Ambulance Class by M.O., 6.30.

Friday, March 2nd.—Technical for Platoon No. 10, Regency Street. Squad and Platoon Drill, No. 9. Signalling Class. Recruits' Drill, 6.25—8.25.

Saturday, March 3rd.—Commanding Officer's Parade. Uniform. 2.45 p.m.

Sunday, March 4th.—Entrenching at Otford. Parade Victoria (S.E. & C. Railway Booking Office), 8.45 a.m.

Easter Camp.—At Esher, where a course has been arranged under Royal Engineer Instructors. Names must be sent in to Orderly Room not later than February 28th.

Telephone Number.—The Telephone at Headquarters is now *Mayfair 1969.*

(By order), Macleod Yearsley, *Adjutant.*

OUR PERSONAL COLUMN.

The Editors invite electrical engineers, whether connected with the technical or the commercial side of the profession and industry, also electric tramway and railway officials, to keep readers of the Electrical Review *posted as to their movements.*

Central Station and Tramway Officials.—Mr. C. C. Atchison, who recently resigned the post of electrical engineer to the Rochdale Corporation, owing to continued ill-health, has been presented with a silver cigarette case by the Rochdale Municipal Officers' Association, of which he has been president for the past two years, in addition to a pair of binoculars from the chief officials, and a pocket aneroid barometer from over 40 pre-war members of the staff at the electricity works.

The Rochdale Corporation Electricity Committee has recommended that Mr. F. H. Rudd, the station superintendent, be appointed acting engineer for a period of three months. Mr. Rudd has been at the works 16 years. During the engineer's recent absence, owing to ill-health, and since his resignation, Mr. Rudd has been in charge of the works.

A sub-committee of the Hull Electricity Committee has recommended an increase of £50 in the salary of the acting engineer, Mr. McGoris, whose services are highly appreciated. He has had entire charge of the undertaking whilst the engineer, Mr. Bell, has been on military duty since the outbreak of the war. The Electricity Committee recommends that the increase be £75, instead of £50.

Mr. J. W. S. Clunas, who was recently appointed city electrical engineer at Cape Town, in succession to Mr. Walter F. Long, has resigned the position in order to take up an appointment with Messrs. Reunert & Lenz, of Johannesburg. Mr. Clunas's salary as city electrical engineer was £900 per annum, and allowance for motor-car.

Mr. Stephen Kirkland, switchboard attendant at the Rawtenstall electricity works, was presented with a timepiece by the staff on the occasion of his marriage.

The L.C.C. Highways Committee recommends that Mr. J. K. Bruce, deputy chief officer of tramways, be appointed traffic manager under the L.C.C. Tramways reorganisation scheme, at a salary of £1,250, rising to £1,500 a year, as from April 1st, and that the position of deputy chief officer be abolished. The special sub-committee appointed to inquire and report upon the organisation and working of the L.C.C. tramways undertaking has expressed its appreciation, which the Highways Committee fully endorses, of the valuable assistance given to it in the consideration of questions arising in connection with the electrical work of the department by Mr. J. H. Rider, formerly electrical engineer in the department, whose advice in many important matters greatly facilitated its work.

The Luton Electricity Committee has decided to increase salaries as follows:—Chief clerk (Mr. R. Harding), from £143 to £156 per annum; general clerk (Mr. F. M. Gregory), from £91 to £104 per annum.

General.—Mr. A. W. Tait, C.A., has joined the boards of Callender's Cable & Construction Co., Ltd., and of the Anchor Cable Co., Ltd.

The salary of Prof. Miles Walker, Professor of Electrical Engineering at the Municipal School of Technology, Manchester, has been raised from £600 to £1,200. It was stated that Prof. Walker had been offered an industrial appointment at £1,800 a year, but preferred to remain in the teaching profession; he was at the head of his branch of electrical engineering in this country, and such men in future would have to be paid salaries of £1,000 to £1,500 a year.

Mr. Hugh Rose, foreman electrician at the Inverurie Locomotive Works, who has received an appointment with Messrs. Claud Hamilton, Ltd., Aberdeen, has been presented by the employés in the electrical department with a case of pipes and a tobacco pouch.

The accompanying illustration, for which we are indebted to the *Ford Times*, is a recent photograph of Mr. Thos. A. Edison, in company with Mr. Henry Ford, of the Ford Motor Co. These two well-known personages have long been

friendly, and a year or so ago it was reported that they were collaborating on the production of a popular-priced electric motor car. So far, however, there is no further news of the new vehicle, and, as Edison is now devoting a good deal of time to the new American Board of Naval Inventions, of which he is the chairman, it is more than probable that the idea has been dropped, or at least postponed until after the war.

Roll of Honour.—Sapper P. F. Groves, R.E., the only son of Mr. W. E. Groves, Birmingham electric supply department, died in France on the 21st ult., aged 19. He was attached to the Army Docks Department as interpreter.

A commission as second-lieutenant in the R.E. has been granted to Mr. E. B. Preston, electrical engineer, of Newcastle-on-Tyne, who enlisted soon after the outbreak of war in the Newcastle Territorial Engineers.

Lance-Corporal A. H. Morgan, Devonshire Regiment, who was for some years on the Exeter staff of the National Telephone Co., and later with the Post Office, has fallen in action in Mesopotamia, at the age of 34 years.

Captain G. C. Milnes, King's Own Royal Lancaster Regiment, who is the electrical engineer for Lancaster, but has been on service since the outbreak of war with the Machine Gun Section of his battalion, has been promoted to the rank of Major. He has been mentioned in dispatches.

The Military Medal for bravery in action has been awarded to Sergeant A. H. Cornwall, R.E., who was trained as an electrician at the works of the Bromley (Kent) Electric Light and Power Co.

First-Class P.O. Chas. R. Allwright, R.N., who joined the service whilst with Messrs. Callender's Co., has been awarded the D.S.M. for gallantry in the Jutland battle, on H.M.S. *Chester.*

Sergeant Jack May, formerly with Messrs. Fraser & Chalmers, of Erith, has been killed in action.

Sergeant James Wright, R.E., has been awarded the Military Medal. He was mentioned in a dispatch from Sir Douglas Haig a few months ago. Before joining the Army he was for 14 years at the Blackburn Corporation electricity works.

Private Harold Fullalove, of the Loyal North Lancashire Regiment, who has died of wounds, was an electrician with the L. & Y. Rly. Co.

Obituary.—Mr. John Rennie.—We regret to announce the death of Mr. John Rennie, the electrician of the Board of Trade Laboratory, and assistant to the Electrical Adviser to the Board of Trade, at the age of 66. At the age of 65 he would, under ordinary circumstances, have retired under superannuation rules, but as he was in full possession of his powers, and had a complete grasp of his work, he was invited to continue his services. About a month ago he was attacked by asthma, and succumbed to heart failure on Monday morning last.

Mr. Rennie was born at Ayr in 1850. During some years at the shipbuilding yards of Messrs. Barclay, Curle & Co., of Glasgow, he worked in the shops, and received practical training as an engineer. At the age of 26, feeling no doubt that the scientific side of engineering attracted him more than the heavy work of a shipyard, he entered the University

of Glasgow, and went through the courses in arts and engineering under Lord Kelvin, then Sir William Thomson. The physical laboratory naturally attracted him, and he held for three years a Thomson Experimental Scholarship. In 1881 he became secretary and private assistant to Sir William Thomson, and witnessed the development of the Kelvin electrical measuring instruments, as well as many other inventions, such as the compass, and assisted also in the scientific researches which were being conducted at that time.

When the Board of Trade Electrical Standards Laboratory was to be founded, Sir William Thomson recommended Mr. Rennie as electrician under Major Cardew, and in thus depriving himself of not only his scientific assistant, but the secretary in charge of his heavy correspondence, he felt that he was placing him in a position of scientific as well as of public importance. Seeing that the legal standards of electrical measurements consisted of Thomson balances and electrostatic voltmeters, Mr. Rennie was obviously the man for the place, and during the 27 years in which the Laboratory was under his charge he proved that these instruments were not only worthy of and suitable for the requirements of those days, but that they were capable of those much higher degrees of precision which are necessary at the present day. If anybody, who did not grasp the difference between a standard apparatus in a standards laboratory and a commercial instrument, ventured to criticise a Kelvin instrument, Mr. Rennie would stoutly defend it, and explain what the "Old Man" was aiming at, and how perfectly those aims were realised. He was proud to point out how many details which had been invented by his master, apparently on the spur of the moment, and perhaps as temporary expedients, had proved to be unsurpassable. When, in 1908, the ampere standard was compared with the ampere balance of the National Physical Laboratory through the intermediary of the Cadmium cell and resistance, an optical appliance was fitted to the Kelvin balance which is used for measuring one ampere, and Mr. Rennie was proud to show that a difference of three or four millionths of an ampere could be easily indicated.

In the early years of the Board of Trade Electrical Standards Laboratory, Mr. Rennie, working under Major Cardew, was actively engaged in the intercomparison of the various standards and sub-standards, and in minute investigation of the instrumental errors; and he arranged a system of records in which the complete history of the important instruments, with details of their corrections from time to time, was entered. Almost every instrument in the Laboratory was known to him, and was alluded to by him, sometimes to the bewilderment of other members of the staff, by its number. After three or four years everything was ready for work. The mere fact that the Laboratory was founded is an indication that there was a demand, and a fairly strong demand, for it among electrical engineers, and it seemed obvious that the work for which it was intended should be started. It was anticipated when he left Glasgow to take up this post that work of commercial value would be done, and that Mr. Rennie's position would become one of importance, but for seven years the Treasury (that is to say, probably some minor official in that department) absolutely vetoed a scale of fees proposed to be charged for the services of the Laboratory to engineers. It is needless to say that the Laboratory did not stand idle, and comparisons were made gratuitously, chiefly for instrument makers. One result of this was that Mr. Rennie received no more than his commencing salary for a long time.

The Laboratory was established to take charge, as it were, of the ampere, the ohm, and the volt, and standards of self-induction and capacity were considered to be outside its scope; but, with the development of electrical engineering, three-phase working opened a ground which the original Kelvin instruments did not directly cover. Mr. Rennie not only kept himself well abreast of the principles of three-phase measurement, but he was also well aware of the practical requirements of engineers as distinguished from those which certain theorists imagined that engineers should employ.

When it became necessary to add suitable wattmeters to the plant in the Laboratory, Mr. Rennie was very exacting in his requirements, and expected more from the instruments than was easily provided, and in several cases the makers had reason to be thankful for suggestions which Mr. Rennie not only made, but insisted upon.

Perhaps the most important work of Mr. Rennie's life was that which he expended upon electric supply meters. The list of meters which the Electrical Adviser recommended to the Board of Trade for official approval, after test by Mr. Rennie and himself, is very far from a complete record of the meters which Mr. Rennie examined. Many strange inventions were submitted to the Laboratory before October, 1891, when the Shallenberger meter was sealed. The fact that, notwithstanding the inadequacy of legislation with regard to meters, so little trouble has been experienced, such excellent meters are in use, and that so few are ever disputed, is the outcome of Mr. Rennie's incessant work on the subject. With his intimate and unique knowledge of the construction of electric meters, he was able to point out to those who submitted types for approval, defects which would only show themselves after prolonged tests. For many years it was his practice to encourage the use of meters by station engineers before the type was approved, in order that practical experience might be obtained in addition to the Laboratory tests. The complete set of tests of a meter could seldom be put through in less than about six months, but one meter, or, rather, one type of meter, remained for ten years under scrutiny, and when at last the approval was given, it is difficult to say how much of the invention was due to Mr. Rennie and Major Cardew.

Mr. Rennie was one of those retiring men personally unknown to many engineers, but well appreciated by those who had to deal with him officially, or on the Engineering Standards Committee, or at the lectures which he gave at Faraday House. He could seldom be induced to take part in discussions at scientific societies, and it is to be regretted that he has published very little. He had very high ideals in human affairs, as well as in engineering and in science. When some verification or comparison had been made with six-figure accuracy, he used to say, "The 'Old Man' would have liked that."

He leaves a widow, two daughters, and two sons. His eldest son, Donald, a graduate of Cambridge, and B.Sc. (London), was a Second-Lieutenant in the 1st Royal Fusiliers, attached to the Royal Warwickshire Regiment, and was killed in action in November, 1914; his second son takes up a commission in the Royal Flying Corps next week, and his youngest is abroad in the Royal Naval Division.

MR. J. H. TUCKER.—We regret to learn that Mr. J. H. Tucker, of the well-known firm of Messrs. J. H. Tucker & Co., electrical accessories manufacturers, Birmingham, died at his home at Solihull on Sunday last, in his 55th year. We understand that Mr. Tucker has not been really well since the summer, but he was taken seriously ill in December, and had since then been unable to attend to business. Mr. Tucker's loss will be very keenly felt by all who have been personally associated with him, but his death will not involve any change in the business or in the firm's policy.

ALD. J. BRODIE.—We deeply regret to announce the death of Mr. Ald. Joseph Brodie, J.P., who had been chairman of the Blackpool Electricity and Tramways Committee uninterruptedly for the past 20 years. He passed away on Monday last, after a long period of illness, at the age of 57. The news will, we are sure, come with sorrow to the very wide circle of friends with whom it was such a pleasure for him to meet at the annual conventions of the Municipal Tramways Association and the Incorporated Municipal Electrical Association. The deceased gentleman, who was always popular, generous, and full of fun, will be remembered as a shrewd, far-seeing, and large-hearted man who played the straight game. From the first day we met him, at one of the early M.E.A. conventions, we struck up a friendship which the passing of years only served to strengthen. In connection with the affairs of Blackpool, his loss will be greatly felt, for he did so much to secure the able administration (under Mr. Chas. Furness) of the tramways and electricity undertakings. The capital of these undertakings when he was first identified with them, in 1896, was only £105,100, and the revenue for that year was a mere £17,720. For 1916, however, the revenue had risen to £124,412, and the capital expenditure stood at £568,000. We extend our heartfelt sympathy to his widow.

MR. E. C. CHURCHWARD.—We regret to learn that Mr. E. C. Churchward, general manager and engineer of the Scottish Central Electric Power Co., Falkirk, died on Tuesday night. The deceased gentleman was appointed to his position at the inception of the company in 1905. He was previously in the office of Messrs. Bramwell & Harris, consulting engineers, who promoted the Scottish Central Co., which operates in the counties of Stirlingshire, Clackmannanshire, and Linlithgowshire.

MR. C. G. MAJOR.—Mr. Charles George Major, chairman of Messrs. Smith, Major & Stevens, lift manufacturers, Northampton, died suddenly on February 15th, from shock after the demise of his wife on the previous day. He resided at Balham, S.W., and had taken an active part in the management of the firm since the establishment of the headquarters at Northampton in 1910.

NEW COMPANIES REGISTERED.

Rotax Motor Accessories Co., Ltd. (145,967).—Private company. This company was registered on February 9th, 1916, with a capital of £175,000 in £1 shares, to take over the business carried on at Rotax Works, Chandos Road, Willesden, as the Rotax Motor Accessories Co., also to carry on business as manufacturers of lighting equipment for railways, tramways, motor cars, and vehicles, &c. The subscribers (each with one share) are: Eugen Aron, Rotax Works, Willesden Junction, N.W., manufacturer; Hermann Aron, Rotax Works, Willesden Junction, N.W., manufacturer; Rowland W. Cox, Rotax Works, Willesden Junction, N.W., general manager; Carl T. F. Benson, Rotax Works, Willesden Junction, N.W., works manager; Arthur Bell, Rotax Works, Willesden Junction, N.W., secretary; Arthur G. Benstead, Rotax Works, Willesden Junction, N.W., electrical engineer. The first directors (to number not less than two or more than seven) are: Eugen Aron and Hermann Aron (both permanent managing directors). Solicitor: A. S. Joseph, 61, Fore Street, E.C. Registered office: Rotax Works, Chandos Road, Willesden Junction, N.W.

Deptford Steel & Ironworks, Ltd. (146,087).—Private company. This company was registered on February 15th, with a capital of £20,000 in £1 shares (10,000 pref. ord.), to take over the business of an electrometallurgist, sherardiser, galvaniser, detinner, &c., carried on by N. C. Mackin as the Deptford Steel and Iron Works and the Homogenous Lead Coating Co. The subscribers (each with one share) are: S. Cole, Sardinia House, W.C., chartered accountant; H. H. Marriott, 10, Victoria Street, S.W., solicitor. The first directors are to be appointed by the subscribers. Solicitors: Kenneth Brown & Co., Lennox House, Norfolk Street, W.C.

Driver, Drennan & Cooper, Ltd. (145,955).—Private company. This company was registered on February 9th, with a capital of £50,000 in £1 shares, to take over the business of cable manufacturers, wire drawers, and electrical engineers and metallurgists, carried on by J. Drennan and J. K. Cooper at Gaythorn Mills, Gaythorn, Manchester, as Drennan and Cooper, and the North-Western Cable Co., and also certain assets in England belonging to the Driver-Harris Wire Co., of Newark, New Jersey, U.S.A., and to enter into an agreement with W. B. Driver and J. Drennan and J. K. Cooper. The subscribers (each with one share) are: F. L. Driver, 70, Aston Street, Newark, New Jersey, U.S.A., president of Driver-Harris Wire Co.; J. Drennan, Kaimhill, Mellor Road, Cheadle Hulme, Ches., electrical engineer. The first directors (to number not less than three or more than five) are: F. L. Driver (chairman), W. B. Driver, A. Bensel, J. Drennan (managing director), and J. K. Cooper. The two last mentioned may retain office for six years. Qualification, £25. Remuneration as fixed by the company. No board or general meeting may be held except for ordinary routine business without the presence of the nominee of the Driver-Harris Wire Co. or his proxy or attorney. Solicitors: Pearson, Prior & Co., 438, Corn Exchange, Manchester. Secretary: J. Drennan.

Chas. W. Cook, Ltd. (145,981).—Private company. This company was registered on February 13th, with a capital of £5,000 in £1 shares, to take over the business of an engineer and scientific apparatus manufacturer carried on by C. W. Cook at Manchester; also to carry on the business of electrical engineers, munition makers, chemical manufacturers, &c. The subscribers (each with one share) are: C. W. Cook, 535, Stretford Road, Old Trafford, Manchester, engineer; C. E. Cook, 535, Stretford Road, Old Trafford, Manchester, engineer. The first directors (to number not less than three or more than seven) are: C. W. Cook (governing director), C. E. Cook, and A. W. Cook. Qualification, £20. Solicitors: Jackson & Newton, 1, Chancery Place, Manchester. Registered office: University Works, Bridge Street, Manchester.

Borra Magneto Repairing Co., Ltd. (146,030).—Private company. This company was registered on February 16th, with a capital of £1,000 in £1 shares (300 pref.), to take over the business carried on by D. Borra, at 72, Dean Street, Soho, W., and to carry on the business of electricians, repairers of magnetos, dynamos, and motor accessories, &c. The subscribers (each with one share) are: D. Borra, 24, Westmead Road, Sutton, Surrey, magneto expert; W. H. M. Burgess, 49, Glasshouse Street, W., merchant; H. J. Prockter, The Gables, Lingfield, Surrey, architect; G. H. Smith & Co. (London), Ltd., 12, Mortimer Street, W., motor accessories manufacturers. The first directors (to number not less than two or more than seven) are: D. Borra, W. H. M. Burgess, H. J. Prockter, and G. H. Smith. Qualification, £1. Remuneration, £52 each per annum. Solicitors: Edmonds & Co., 13, Clifford's Inn, E.C. Secretary: C. G. Larrette. Registered office: 72, Dean Street, Soho, W.

Associated British Machine Tool Makers, Ltd. (145,999).—Private company. This company was registered on February 14th, with a capital of £100,000 in £1 shares, to carry on the business of machinery and engineering tool manufacturers, mechanical, electrical, and general engineers, makers of sand blast machinery, air compressors, metal cleaning apparatus, oxygen and hydrogen gas plant, textile and wood working machinery, appliances used in the manufacture of machine and other guns, motor cars, cycles, and aircraft, &c. The subscribers (each with one share) are: W. B. Lang, The Grange, Johnstone, near Glasgow, engineer; G. W. Gregory, 9, Birch Lane, Manchester, engineer; S. A. Smith, New Holme, Harboro' Road, Ashton-on-Mersey, manufacturer; G. Thompson, Shepperton, Selly Wick Road, Birmingham, manufacturer; W. F. Clark, Bartley Cottage, Northfield, Birmingham, engineer; W. G. Shanks, Melfort House, Milliken Park, near Glasgow, engineer; S. H. March, Redclyffe, Chorlton-cum-Hardy, engineer; H Butler, Fern Bank, Halifax, engineer. The first directors (to number not less than five or more than 15) are: W. F. Clark, J. W. S. Asquith, S. H. March, A. H. Baldwin, W. B. Lang, A. E. Matthewson, W. G. Shanks, W. D. Ford-Smith, E. Williams, and H. Butler. No person may be a director or a member of any committee appointed by the board unless he is a member of the company, or is a partner in a shareholder firm, or is a director or official of a company which is a shareholder in this company. Remuneration (if any) to be fixed by the company. Solicitors: W. A. Crump & Son, 17, Leadenhall Street, E.C. Registered office: 34, Victoria Street, S.W.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Perfect Burglar Alarm, Ltd. (112,522) (originally known as Lichtenfeld Burglar Alarm Co., Ltd. Renamed January 13th, 1915.) Capital, £4,000 in £1 shares (1,000 pref.). Return dated December 29th, 1916. 230 pref. and 1,710 ord. shares taken up; £1 per share called up on 1,210 shares and 15s. per share on 230; £1,380 paid, leaving £2 10s. in arrears; £500 considered as paid on 500 shares. Mortgages and charges: Nil.

Porous Accumulator Co., Ltd. (57,526).—Capital, £3,000 in £1 shares. Return dated December 30th, 1916. All shares taken up; £1,007 paid; £1,993 considered as paid. Mortgages and charges: Nil.

CITY NOTES.

London Electric Railway Companies.

The reports of the Central London Railway, the London Electric Railway, the Metropolitan District Railway, the City and South London Railway, and the London General Omnibus Companies for 1916 have been issued. The aggregate gross receipts of the five companies from all sources were £6,038,529. The companies retained for revenue liabilities, as per agreement, £5,531,562, and the balance of £506,968 was credited to the common fund. Of this amount, the Central London Railway takes 20 per cent., the London Electric Railway 30 per cent. (as against 26 per cent. for 1915), the Metropolitan District 12 per cent., and the City & South London 6 per cent. (as against 2 per cent. for 1915). The total number of passengers carried by the companies and the average fare per passenger cannot be given, as the District is still under Government control, and its figures are not available.

Central London Railway.—Total net income £184,492, plus £15,686 brought forward; interest, rentals, and other fixed charges absorb £41,499; reserve takes £20,000; dividend on preference stock £21,600. For the year the ordinary dividend is 3½ per cent., and that on the preferred ordinary 4 per cent., and on the deferred ordinary stock 3 per cent., leaving £12,079 to carry forward. The increased appropriation to reserve (£10,000 more than for 1915) is due to the uncertain outlook, the high price of materials and labour, and the impossibility of securing all the materials required for the compete maintenance of the property during the year. Capital expenditure during the year, £12,295. The construction of the extension railway between Wood Lane and Ealing Broadway is making slow progress owing to the war. An administrative staff superannuation fund has been established jointly with the other companies. The company is actively interested in the "Safety First" campaign. Sir Albert H. Stanley having been appointed president of the Board of Trade, resigned his position with the company, and Mr. W. C. Burton, a new director, becomes managing director. Meeting: To-day.

London Electric Railway Co.—Total net income £590,190, plus £12,303 brought forward. Interest, rentals, and other fixed charges require £276,153; there is put to reserve £35,000; dividend on preference stock absorbs £126,947. Dividend on the ordinary shares 1½ per cent. for the year, carrying forward £24,474. The reserve appropriation is £15,000 higher than last year, for reasons stated above. Capital expenditure during 1916, £39,257. The manufacture of the joint rolling stock for the through running of trains from the Bakerloo section of the railway to Watford having been delayed by the war, arrangements have been made with the L. & N.-W. Rly. whereby the London Electric Railway will, for the present, provide the necessary rolling stock and operate the train service. It is hoped to commence through running at an early date. The references above to superannuation, safety first, and to the managing directorship all apply to this company as well. Meeting: To-day.

Metropolitan District Railway Co.—Total net income £565,765, plus £13,952 brought forward. Interest, rentals, and other fixed charges require £344,999. There is appropriated to reserve £45,000 (as compared with £35,000 in 1915); dividends on guaranteed and first preference stock absorb £124,930; 3 per cent. is paid on the second preference stock, and £20,688 is to be carried forward. Capital expenditure during the year, £2,475. The above remarks respecting the safety first campaign and the managing directorship both apply in the case of this company. Meeting: To-day.

City & South London Rly. Co.—Total net income £124,488, plus £9,027 brought forward. Interest, rentals, and other fixed charges absorb £31,570; there is put to reserve £20,000 (increase £10,000); preference dividend £42,500. Dividend, 1½ per cent. on consolidated ordinary stock, carrying forward £17,245. Capital expended during 1916, £24,850. The above references to superannuation, safety first, and the managing directorship also apply to this company. Meeting held on Tuesday.

Smithfield Markets Electric Supply Co., Ltd.

The gross profit for 1916 was £3,797, against £4,250 for 1915; the net profit was £2,467, compared with £2,816. £400 has again been placed to debenture stock redemption fund, and £1,250 to depreciation account. The balance remaining, including £1,296 brought forward, is £2,113. A dividend of 1 per cent. on the ordinary shares requires £600, £500 is written off cost of change of pressure, and £1,013 is to be carried forward. The profits have been adversely affected by the fire at the station in October. The service to the markets was interrupted for some days pending arrangements for a temporary supply, and it was then decided, in order to provide against similar interruption in the future, to retain that supply as a permanent stand-by, and to alter the pressure of the company's own system to conform thereto. The cost of the change so far incurred appears in the accounts (£938, plus amount written off), and will be gradually liquidated out of revenue spread over a period of three years. The damage caused by the fire was fully covered by insurance. For the first nine months of 1916 the sale of current increased satisfactorily. Higher costs of production were met to some extent by increasing the charges; a further rise in prices of the principal commodities is expected. The Diesel plant installed in the spring has proved entirely satisfactory.

South Metropolitan Electric Light & Power Co., Ltd.

For the year 1916, the revenue account shows a credit balance of £50,510, which with £6,605 brought forward and £1,102 dividend of 10 per cent. on the holding in the West Kent Electric Co., Ltd., makes £58,216. After deducting £12,589 for interest on debenture stock, paying 7 per cent. on the first preference and 6 per cent. on the second preference shares, £17,600 is put to depreciation, 4 per cent., less income-tax, is paid on the ordinary shares, leaving £7,249 to be carried forward. The comparative figures for two years are:—

	1915.	1916.
H.P. connected	19,389	21,411
Number of consumers	6,781	6,985
Gross revenue	£80,576	£95,883
Expenditure	£31,386	£45,373
Net revenue	£49,190	£50,510

The gross revenue shows a further substantial improvement, but owing to the high price of coal nearly the whole of the increase has been absorbed in extra expenditure. The new 5,000-KW. turbo-generator has been put to work, and in order to deal with the growth of the business another of 5,000 KW. has been placed on order. With the sanction of the Treasury, £29,140 4½ per cent. first debenture stock and

5,440 6 per cent. cumulative second preference shares were issued during 1916. The West Kent Electric Co., Ltd., more than doubled its gross receipts, and the net revenue increased from £3,051 to £5,432. Annual meeting: February 28th.

Westminster Electric Supply Corpn., Ltd. During 1916 the connections to the mains increased from 42,355 KW. to 43,969 KW. Lieut.-Col. J. F. Remnant, M.P., has been elected to fill the vacancy caused by the retirement of the Rt. Hon. W. Hayes Fisher, M.P. After allowing for depreciation, sinking fund and other charges, and preference interest, the total dividend for the year on the ordinary shares is 7 per cent., carrying forward £2,952. Units sold to consumers, 23,498,812 (including A.C. supply of 1,230,332, used on works 320,911, total 23,819,723). The revenue from sale of current was £228,817, as against £213,416 in 1915. The total revenue was £262,624, against £247,060 in 1915. The expenses on revenue account totalled £196,331, against £185,969. Coal, &c., cost £21,495, against £17,462. Annual meeting: February 28th.

St. James' and Pall Mall Electric Light Co., Ltd. During 1916 the connections increased from 16,305 KW. to 16,631 KW., and 11,272,368 units were supplied to consumers. The Central Electric Supply Co. has determined to pay no dividend on its shares for 1916. The net profits of the St. James' Co. were £22,842, plus £2,752 brought forward. After paying 7 per cent. for the year on the preference shares, and a total of 8 per cent. on the ordinary for the year, £2,595 is to be carried forward. The sale of electricity produced £136,448, and the total revenue was £143,072; the expenses on revenue account were £115,077, leaving £27,995 to carry to net revenue. The deaths of Messrs. Bennett Fitch and S. T. Dobson are recorded with regret. Units generated by steam plant 664,076, purchased 13,817,632, = 14,481,708. Units sold, &c.: Private supply 11,272,368, works 263,757, batteries 250,072, transmission and transformation 2,107,260, distribution, &c., 588,251. Annual meeting: February 27th.

National Electric Supply Co., Ltd.—The annual meeting was held at Preston last week. Mr. JOHN BOOTH, the chairman, said that the company had been disappointed in regard to the new turbine plant which had been delayed in delivery, and this had handicapped them in dealing with a growing output under very trying conditions. Notwithstanding daylight saving and lighting restrictions, the total output had increased by 22.8 per cent., due to the increased demand for power purposes; and the total income had increased by £2,250. The sale of current for lighting was £1,310 less than in the previous year. Coal cost £2,675 more, wages increased by £249, and rates and taxes by £463. The capital account had been increased by £7,000, chiefly in payment for the new turbine set. It was proposed to put £4,000 to reserve for depreciation. The company started the new year with promising prospects, for they had a record load and were in a better position as regards machinery than for many years. Dividends at the rate of 4 per cent. on the preference and 3s. 6d. on the ordinary shares, making 6s. for the latter for the year, were declared.

The War Loan.—The following applications for War Loan were announced after we went to press last week:—

	New money.	Total.
	£	£
Endolithic Manufacturing Co.	(12,200)	12,200
Monte Video Telephone Co.	(41,500)	50,000
Staff and Employés, G.E.C., additional	(13,500)	40,000
Fraser & Chalmers' Employés	(5,000)	5,000
C. A. Vandervell & Co.		64,800
British Westinghouse E. & M. Co.	(50,000)	60,000
National Gas Engine Co.	(75,000)	200,000
Falk, Stadelmann & Co., Ltd., and Directors	(26,100)	54,000
Mrs. Salomon Falk (widow of the late Mr. S. Falk, and founder of Falk, Stadelmann & Co.)	(5,000)	12,200
Miss Audrey Falk (daughter of the late Mr. S. Falk and Mrs. Falk)	(250)	1,426
Mawdsleys, Ltd. (Directors and Staff)		58,000

Tyneside Tramways & Tramroads Co.—For the half-year ended December, the surplus of receipts over expenses was £6,223, plus £700 brought forward. A dividend on the ordinary shares at the rate of 4¼ per cent. per annum (less income-tax), makes with the dividend paid in September 3 per cent. for the year. There is put to reserve for renewals, depreciation, and other contingencies £1,400, to special reserve £400, leaving to be carried forward £665. The traffic receipts increased by £1,705, and for the whole year there is an increase of £687.

Kaministiquia Power Co., Ltd.—The gross revenue last year was 366,800 dols.; operation and maintenance, 48,378 dols.; depreciation and renewal reserve, 29,000 dols. (in addition to 6,000 dols. appropriated on monthly basis during the year); net revenue, 289,422 dols.; fixed charges, 96,125 dols.; net income, 193,297 dols. The rate of dividend on the stock was increased during the year from 6 per cent. to 7 per cent. Surplus earnings of 50,557 dols. have been transferred to general surplus, which now stands at 336,697 dols.—*Financier.*

Central Electric Supply Co., Ltd.—During 1916 the company supplied 30,059,660 units to the Westminster, St. James', and Chelsea Companies. The deaths are regretted of Mr. Bennett Fitch and Mr. S. T. Dobson. The Rt. Hon. G. W. Balfour has been appointed a director. The financial result has been already announced here.

Lancashire United Tramways, Ltd.—The report for 1916 states that the net profit is £33,105. The receipts increased £12,979. The increase in expenditure was £8,775, due to the additional output of electrical energy and to increased charges for materials and labour. The interest and dividends received from the operating companies, together with sundry receipts, amounted to £16,782. After deducting interest on the prior lien debenture stock and expenses, there remains £3,024. Out of this interest will be paid on the second mortgage debenture stock for 1916 at the rate of 1 per cent., which will absorb £2,965, and £59 is carried to depreciation account. There is also a balance on the year's working of the operating companies, after payment of the interest and dividends, of £17,580. —*Financial Times.*

Para Electric Railway & Lighting Co., Ltd.—For the year ended November 30th the gross receipts increased from £243,483 in 1915 to £271,691. The operating expenses increased from £115,309 to £123,403, the net revenue earned in Para being, therefore, £148,288, as compared with £128,174, the revenue of the previous year. As the accounts are based upon the legal exchange rate of 16d. per milreis, there must be deducted £42,803, being the actual loss incurred on remittances. After providing for this loss on exchange and London expenses, the balance of operating revenue is £100,675, compared with £90,759 of the previous year. The net revenue in milreis during the past year was the largest yet obtained by the company. After paying debenture charges and preference dividend, a dividend of 6 per cent. on the ordinary shares, less income-tax, £25,572 is to be carried forward.—*Financial Times.*

Newcastle & District Electric Lighting Co., Ltd.—The profit for 1916 was £39,364, plus £27,823 brought forward. Interest on debentures and loans absorbs £18,548, £2,395 is put to second mortgage debenture redemption fund, £10,000 is put to reserve, 2½ per cent. per annum, less income-tax, is to be paid on the shares, and £29,979 carried forward. The profit would have enabled a larger dividend to be paid, but coal costs and war conditions render it wise to restrict it to 2½ per cent. The year's capital expenditure was £9,793. A further £2,500 of the 6 per cent. second mortgage debentures have been redeemed.

Fife Tramway, Light & Power Co.—The profits for the year, after paying loan interest, &c., are £23,771. The half-year's 6 per cent. dividend on preference shares (£4,817) was paid, and after paying the balance due on these, setting aside £3,289 in paying 4½ per cent., less tax, on the ordinary shares, and carrying £3,000 to the reserve account, £8,164 will be carried forward. The revenue from shares and management fee from Dunfermline & District Tramways Co. was £15,000, and from the Fife Electric Power Co.'s electric lighting undertaking £14,671.

Electrical Distribution of Yorkshire, Ltd.—The net profit for 1916 was £3,495, against £3,638 for 1915 and £2,964 for 1914. The amount brought forward was £905. A dividend of 6 per cent. (free of income-tax) on the ordinary shares absorbs £2,532, £1,000 is put to reserve, and £869 is carried forward subject to directors' remuneration. Having regard to lighting restrictions, increased expenditure, and other difficulties, the results are satisfactory. In February, 1916, 8,134 £1 shares were allotted. Applications have been made for electric lighting orders for supply in other districts in the West Riding.

London Electric Supply Corporation, Ltd.—It is stated that the directors have declared 1 per cent. on preference shares for the past half-year, making 4 per cent. for year; £7,068 forward. Last year, 3 per cent. on ordinary shares for year, £5,000 to contingencies account, £9,050 forward.

Blackpool & Fleetwood Tramroad Co.—Final dividend of 4½ per cent. (making 6½ per cent. for the year) absorbs £6,750. There is put to general reserve £1,000, to depreciation reserve £5,000, writing down value of investments in railway stock £3,005. £15,755 is carried forward, subject to excess profit duty £3,750.

Bournemouth & Poole Electricity Supply Co., Ltd.—Subject to audit, final dividend on the ordinary shares 7 per cent. per annum, less income-tax, for the last half-year, making 6 per cent for the year.

Mersey Railway Co.—The available revenue for 1916 was £21,299, as against £21,442 for 1915. This is being distributed as follows:—4 per cent. on 1866 debenture stock, 3 per cent. on 1871 ditto, 3 per cent. on 1882/3/5 ditto, 1 per cent. on the "B" debenture stock; carry-forward £21.

Oxford Electric Co., Ltd.—Dividend at the rate of 2½ per cent., less income-tax, on the ordinary shares for the half-year ending December 31st last, being a distribution for the year at the rate of 5 per cent.

South London Electric Supply Corporation, Ltd.—Subject to final audit, dividend on ordinary shares at the rate of 5 per cent. per annum for the year 1916, placing £7,550 to depreciation fund, and carrying forward £3,053.

Mather & Platt, Ltd.—Dividend on the ordinary shares at the rate of 17½ per cent. per annum, less income-tax, and less the interim dividend of 5 per cent. already paid for the year.

Vulcan Boiler & General Insurance Co., Ltd.—For 1916, the net profit was £62,689, including £8,338 brought forward. The dividend and bonus is 25 per cent., less tax.

South Staffordshire Tramways Co., Ltd.—The directors recommend a dividend of 4 per cent. on preference shares, carrying forward £844.

STOCKS AND SHARES.

TUESDAY EVENING.

THE success of the War Loan has had a marked influence upon the Stock Exchange. Before the figures were announced, there was a general tendency throughout the markets which showed that they were relieved at the closing of the subscription lists, and looked for better business, which, of course, means better prices. Mr. Bonar Law's announcement on Monday night was regarded as eminently satisfactory; and a smart improvement in the price of Consols had a sympathetic effect all round the House. The liveliest interest of the moment is centred upon sweepstake tickets, in which an active market has sprung up on the basis of 20s. premium for the 20s. tickets.

The only unpleasant spot in the markets with which we deal is the passing of the dividend on the ordinary shares by the London Electric Supply Corporation. Not only so, but the company has also reduced the dividend on its preference from 6 per cent. to 4 per cent. The reason, of course, is the unforeseen event of last autumn, but this at the time was understood, at any rate by a good many people, to be of moderate dimensions, and not likely to imperil the maintenance of the full dividend on the preference shares. The price of the latter has fallen 10s. to 3¾, and that of the ordinary shares 5s. to £1, both of these, however, being decidedly nominal—that is to say, sellers find it difficult to place shares when they want to realise.

On the other hand, the West End reports continue good. The St. James' & Pall Mall repeats its previous distribution of 8 per cent. for the year, and this time is not obliged to cut into the contingency fund as it had to do in 1915. The net profit of £23,000 is about £3,000 higher than that of the preceding twelvemonth. The Westminster Electric has issued its report, showing progress which, considering all the circumstances, is decidedly satisfactory. The Central Electric Supply Co. passed its dividend, as it did in 1915. Quotations are steady, but there is not a great deal of business going on. More is doing, however, in the shares of the manufacturing companies; and in such issues as British Aluminium a fair volume of trade is being transacted.

The various Tube reports are now available, but, as usual, the form in which they are presented does not enable much information to be gathered as to the real earnings of the different companies. The London General Omnibus Co. is the basis upon which the others practically rest; and in this case, as we mentioned last week, the dividend was reduced from 12 per cent. to 8 per cent. for the year. All the five companies in the pool—*i.e.*, the District, City & South London, Central London, London Electric, and London General Omnibus Companies—report the aggregate traffic earnings at £5,279,000, which was swollen by other receipts to just over £6,000,000, both marking substantial advances over the earnings of the corresponding period. It is interesting to note the sums which the various companies take out of the pool; and in comparing them with those of 1915, we get the following table:—

	1916.	1915.
	£	£
London General	162,200	180,500
London Electric	152,100	117,400
Central London	101,400	90,300
Metropolitan District	60,900	54,200
City & South London	30,400	9,000

The City & South London increase is mainly due to the fact that the company gets 6 per cent. out of the pool now, as against 2 per cent. previously, while the London Electric Co. draws 30 per cent. instead of 26 per cent., the 8 per cent. being taken from the proportion paid to the London General Omnibus Co., so accounting largely for the reduction in the dividend on the latter. The market in the various stocks and shares has improved with that for other railway stocks; and Underground Electric incomes, after being down to 83, now stand at 85, while the £10 shares moved up 5s. to 1⅛. Steam-electric stocks are also harder. It cannot be said that there has been much increase of business to fortify this week's improvements.

The Treasury has now published its list of securities of which it demands delivery in accordance with a recent order under the Defence of the Realm Act. Amongst these securities figure the 4½ per cent. bonds of the New York Telephone Co. The remainder of the list is principally made up of bonds of various American railways, and the only surprise felt with the list is that it should be necessary for the Treasury to take steps which would not have been called for had the bondholders supported the previous Scheme B put forward by the Treasury with a view to assisting the exchange problems.

Telegraph and cable stocks are better on the whole, in company with other industrial securities. The Eastern group is harder, and in various other parts of the market the recent weakness brought about by realisation of their stocks by holders who wanted to utilise their money in the War Loan, has given way to a more robust tone as the bargain-hunters came to pick up what was cheap. The principal excitement, however, has shifted again to Marconi shares, the price rising to £3 under the stimulus of buying produced by further vague optimisms as to the profits which the company is now earning and the amount which the Government may be expected to hand over in payment for services since the outbreak of war. The shares of the subsidiaries are also better, Americans improving to 16s. 9d., and Canadians to 8s. 9d.

British Aluminiums are a lively spot, with an advance of 1s. on the week to 28s. Dividend anticipations are responsible for the buying. The shares on the outbreak of war stood at their par value of £1. Edison Swan have also come into demand as a result of the meeting at which the scheme for reorganisation of the capital was approved; the shares rose to 10s., and the other issues are also better.

Babcock & Wilcox, in the engineering group, have gained half-a-crown; and the fresh attention paid to chemical shares has brought about a rise of 3s. 9d. in Castner-Kellners. There is a noticeable increase of interest paid by the public to industrial shares of all kinds, and the rubber market has fully participated, business improving and prices rising in steady fashion day by day. Vickers and Armstrongs are also harder; while the high-priced shares of the industrial groups are becoming difficult to obtain. Henley's, however, are dull on the offer of a mere handful of shares. A fall of 5s. occurred in General Electric preference.

SHARE LIST OF ELECTRICAL COMPANIES.

	Dividend 1914.	Dividend 1915.	Price Feb. 20, 1917.	Rise or fall this week.	Yield p.c.
HOME ELECTRICITY COMPANIES.					
Brompton Ordinary	10	10	6⅝	—	£7 11 0
Charing Cross Ordinary	5	5	3⅝	—	7 8 2
do. do. do. 4½ Pref.	4½	4½	3 15/16	—	6 16 10
Chelsea	5	4	3	—	6 18 4
City of London	9	8	11	—	7 5 5
do. do. 6 per cent. Pref.	6	6	9½	—	6 8 4
County of London	7	7	10	—	7 0 0
do. 6 per cent. Pref.	6	6	9½	—	6 6 4
Kensington Ordinary	9	7	6⅜	—	6 10 3
London Electric	4	3	1	— ¼	Nil
do. do. 6 per cent. Pref.	6	6	3⅜	— ¼	5 6 8
Metropolitan	8½	6	2½	—	6 13 4
do. 4½ per cent. Pref.	4½	4½	3¼	—	7 4 0
St. James' and Pall Mall	10	8	6	—	6 13 4
South London	5	5	2⅞	—	6 19 0
South Metropolitan Pref.	7	7	1 5/16	—	6 7 8
Westminster Ordinary	9	7	5⅜	—	6 4 5
TELEGRAPHS AND TELEPHONES.					
Anglo-Am. Tel. Pref.	6	6	94	— ½	6 7 8
do. Def.	80/-	33/6	22	—	6 16 4
Chile Telephone	8	8	7 15/16	— 1/16	5 15 3
Cuba Sub. Ord.	5	5	8½	—	6 8 6
Eastern Extension	7	8	13⅜	—	*5 16 4
Eastern Tel. Ord.	7	8	137	+2	*5 16 10
Globe Tel. and T. Ord.	6	7	11½	— ½	*5 19 2
do. Pref.	6	6	9¾	—	6 3 1
Great Northern Tel.	22	22	34	—	6 9 5
Indo-European	13	13	46½	—	5 19 9
Marconi	10	10	3	+ ⅛	3 6 8
New York Tel. 4½	4½	4½	101	—	4 9 0
Oriental Telephone Ord.	10	10	2 1/16	+ 1/16	4 16 10
United R. Plate Tel.	8	8	6⅜	—	*8 5 6
West India and Pan.	1	6d.	1	—	2 4 0
Western Telegraph	7	8	13⅜	—	*5 16 4
HOME RAILS.					
Central London, Ord. Assented	4	4	62½	—	6 8 0
Metropolitan	1½	1	24	+1	4 8 4
do. District	Nil	Nil	16	—	Nil
Underground Electric Ordinary	Nil	Nil	1⅞	+ ⅛	Nil
do. do. "A"	Nil	Nil	5/6	+6d.	Nil
do. do. Income	6	6	85	+1	*5 17 8
FOREIGN TRAMS, &c.					
Adelaide Sup. 6 per cent. Pref.	6	6	4¼	—	6 1 6
Anglo-Arg. Trams, First Pref.	5½	5½	2 15/16	— 1/16	9 7 2
do. 2nd Pref.	5½	5½	2⅜	—	—
do. 5 Deb.	5	5	64⅞	—	7 15 0
Brazil Tractions	4	4	48½	+1	8 5 0
Bombay Electric Pref.	6	6	10	—	6 0 0
British Columbia Elec. Rly. Pfce.	5	5	61	—	8 4 0
do. do. Preferred	—	Nil	43	—	Nil
do. do. Deferred	—	Nil	37½	—	Nil
do. do. Deb.	4½	4½	64	—	6 12 10
Mexico Trams 5 per cent. Bonds	—	Nil	25	—	Nil
do. 6 per cent. Bonds	—	Nil	22½	—	Nil
Mexican Light Common	Nil	Nil	7⅛	—	Nil
do. Pref.	Nil	Nil	14½	—	Nil
do. 1st Bonds	Nil	Nil	27½	—	—
MANUFACTURING COMPANIES.					
Babcock & Wilcox	14	15	2⅜	+ ⅛	5 9 1
British Aluminium Ord.	5	7	28/-	+1/-	5 7 2
British Insulated Ord.	15	17½	11⅜	—	7 7 4
British Westinghouse Pref.	7½	7½	2 3/16	+ 3/16	6 11 3
Callenders	15	20	12½	—	8 4 0
do. 5 Pref.	5	5	4	—	6 5 0
Castner-Kellner	20	22	8⅜	+ 3/16	6 10 3
Edison & Swan, £8 paid	Nil	—	⅛	+ 1/16	Nil
do. do. fully paid	Nil	—	⅛	—	Nil
do. do. 4 per cent. Deb.	4	4	61½	—	6 10 1
Electric Construction	6	7½	1	—	7 10 0
Gen. Elec. Pref.	6	6	9½	— ½	6 9 9
do. Ord.	10	10	18⅜	—	7 5 6
Henley	20	25	15½	— ½	8 4 0
do. 4½ Pref.	4½	4½	4	—	5 12 6
India-Rubber	10	10	11⅛	— ⅛	*8 10 2
Telegraph Con.	20	20	37	—1	*8 15 2

* Dividends paid free of income-tax.

FREQUENCY CHANGERS.

By R. TOWNEND, A.M.I.E.E.

(*Abstract of paper read before the* Institution of Electrical Engineers.)

Frequency changers may be divided broadly into three classes:—

1. Where the electrical energy is converted electro-magnetically from one frequency to the other (by transformer action).

2. Where part of the energy is converted electro-magnetically and the remainder converted into mechanical energy, and then, in some cases, back again into electrical energy.

3. Where the energy is converted into mechanical energy, and then again into electrical energy.

The first of these types has been described in a paper read before the Institution, but, as the only ratio of frequency conversion obtainable is 1 to 3 (or multiples of this value) its scope is limited.

The second type usually takes the form of an induction motor mechanically coupled to some form of driving motor. If an electromotive force having a certain frequency is applied to the stator terminals of a slip-ring induction motor, the rotor of which is fixed so that it cannot rotate, the motor operates as a transformer, the slip-ring voltage being determined by the ratio of the number of turns in the stator and rotor windings, and its frequency being the same as that of the stator supply. If the rotor is allowed to rotate, its speed being held constant at any desired value, either by a friction brake or by coupling it to a generator, the rotor frequency is reduced.

If the rotor is rotated by means of a driving motor in the opposite direction to that in which it normally tends to rotate, the rotor frequency is increased.

If the rotor were allowed to rotate at half synchronous speed in its normal direction, and neglecting the losses in the machine, of the power supplied to the stator 50 per cent. would be given out of the rotor at half the stator frequency, and 50 per cent. would be given out mechanically to the direct-coupled machine which now operates as a generator.

With this arrangement it is therefore possible, by using a variable-speed driving motor, to obtain any frequency from zero to a value limited by the maximum safe running speed of the induction motor.

Its bad inherent voltage regulation has prevented this type of machine from being used commercially to any extent, but it is certainly a very useful form of frequency changer for experimental or testing purposes where high-frequency power is occasionally required, and the question of voltage regulation is of little importance.

The third type of frequency changer consists of an alternating-current motor driving a synchronous alternating-current generator. The motor may be either of the induction or of the synchronous type, the former giving what we will call the induction frequency changer, and the latter the synchronous frequency changer. The generator may be of the induction type, but this is very seldom adopted owing to the well-known disadvantages of generators of this type.

As the motor and generator are not electrically connected together, each machine can be designed for any desired voltage and number of phases, so effecting a change in both voltage and number of phases, in addition to the change in frequency, if this should be required. It is thus possible to obtain single-phase power at a low frequency for traction work from a polyphase high-frequency supply without unbalancing the latter. Also by controlling the generator voltage by means of an automatic regulator, its pressure can be maintained constant independent of variations in either the voltage or frequency of the supply.

The number of poles on the motor and the generator must have the same ratio as the motor and generator frequencies (neglecting the slip in the case of the induction frequency changer), and this, of course, determines the maximum speed for which the set can be designed. Thus a set converting from 25 to 50 periods may have a 2-pole motor and a 4-pole generator, giving an operating speed of 1,500 r.p.m., whereas a set converting from 25 to 60 periods has a maximum speed of 300 r.p.m., corresponding to a 10-pole motor and a 24-pole generator. If, however, it is permissible to lower the 25-period supply to 24½ periods, and raise the 60-period supply to 61½ periods, a speed of 735 r.p.m. could be adopted corresponding to a 4-pole motor and a 10-pole generator.

In the case of the induction frequency changer, the ratio of the two frequencies varies to a small extent with the load, due to the varying slip of the induction motor, and with the number of poles just mentioned an exact conversion ratio of 25 to 60 periods would be obtained at a load corresponding to a motor slip of 4 per cent.

The question whether to adopt induction or synchronous motors depends upon the conditions governing each case. If it is essential that the ratios of the frequencies should be constant at all loads, that the power factor of the motor should be under the control of the operator, or that the set should be perfectly reversible (by perfectly reversible is meant that the motor will operate as a generator without requiring synchronous machines in parallel with it), it is necessary to adopt synchronous frequency changers. Where these requirements do not apply, the induction set has advantages, particularly from the point of view of the operator, as the paralleling of, and load distribution between, induction frequency changers are usually simpler than is the case with synchronous sets.

Where two stations have to be coupled by means of frequency changers, it may be preferable under certain conditions to use induction sets, as they form a connecting link having the nature of a slipping clutch, whereas synchronous sets have the characteristic of a rigid coupling.

Induction Frequency Changers.

Starting is effected in the manner ordinarily adopted for induction motors; if of the squirrel-cage type, a low voltage is switched on to the stator terminals, and when full speed is reached, the starting switch is thrown over to the full-voltage position; with this arrangement the starting current in the line will be approximately 100 to 150 per cent. of normal full-load current. In the case of the slip-ring motor, normal voltage is applied to the stator terminals, and the resistance connected across the rotor slip-rings is gradually cut out as the motor speeds up. With this type of motor, the starting current will be approximately 30 to 50 per cent. of normal full-load current.

Where induction frequency changers have to operate in parallel, the slip-ring type of motor is preferable, as it enables the generator to be synchronised more easily.

Considering the case where a frequency changer running on no load has to be paralleled with a similar set carrying full load, owing to the slip of the induction motor varying directly with the load, the incoming set will be running at a higher speed than the loaded set, and in order that the generators may be safely paralleled it becomes necessary to increase the no-load slip of the incoming set to a value approximately the same as that of the loaded set. If the fully-loaded machine has a slip of 3 per cent., the incoming machine will have a slip approximately 0.2 per cent. (assuming the resistance of the rotor circuits to be the same in each case), and if the generators have a frequency of 50, a synchroscope connected to the two generators will make a complete revolution in 0.71 sec., under which condition safe paralleling is an impossibility. It is, therefore, necessary to increase the slip of the incoming machine before the paralleling can be effected.

This increased slip may be obtained either by artificially loading the incoming set, or by increasing the resistance of the rotor circuits of the motor. If the motor is of the squirrel-cage type, its rotor resistance is fixed, and it is therefore necessary to adopt the first method in order to obtain the desired slip.

In the case of the slip-ring motor, the second method can be adopted, and is obviously more desirable than having artificially to load the machine. It should be noted, however that as the motor is running on practically no load, the resistance required in the rotor circuit is considerably higher than is usually supplied for starting the set.

An alternative method which is frequently adopted when paralleling induction frequency changers is to allow the incoming machine to run up to full speed, and when the generator is giving its correct voltage, power is cut off from the motor, and the generators paralleled at the instant the frequency of the incoming generator falls to that of the loaded machine.

When two or more sets are operating in parallel, the load taken by each will depend upon the full-load slip of the different motors, and if a distribution proportional to their relative capacities is desired, each motor must have the same percentage slip at full load.

With slip-ring motors this can be obtained by means of the external resistance in the rotor circuit, but as this precludes the use of brush-lifting and short-circuiting gear, it is desirable that the motors should be designed to have the correct slip with the slip-rings short-circuited.

With slip-ring motors, the load can be distributed as desired between the different sets, but with squirrel-cage motors this cannot be achieved, as each set must carry a definite proportion of the total load, dependent upon its slip at full load.

The induction frequency changer can transmit power in the reverse direction, *i.e.*, with the induction machine running as a generator, provided there are synchronous machines running in parallel with it, having a capacity large enough to supply not only the wattless current required to magnetise the induction machine, but also the wattless component of the total load on both the induction and synchronous machines.

When operating as a generator, the induction machine must run above the synchronous speed, and as in the case when motoring, the slip varies with the load, equal slips above and below the synchronous speed corresponding to equal outputs as generator and motor respectively.

In order to obtain the advantages of the induction frequency changer, and at the same time to obtain perfect reversibility, two induction sets may be used; one set having a low-frequency induction machine coupled to a high-frequency synchronous machine, and the other a high-frequency induction machine coupled to a low-frequency synchronous machine. A pair of frequency changers of this type has been installed in South Wales to link up two stations

generating at frequencies of 40 and 50 periods. The stations were of a capacity sufficiently large to make the adoption of synchronous sets undesirable, but it was necessary that the frequency changers should be able to operate in the case of either station being unable to supply power. One set consists of a 10-pole synchronous machine coupled to an 8-pole induction machine, and the other set of a 10-pole induction machine coupled to an 8-pole synchronous machine. The combined output of the two sets is 1,000 KW., the K.V.A. output being limited by the K.V.A. capacity of the synchronous machines, owing to the synchronous generator having to supply the magnetising current of the induction generator in parallel with it, and also the wattless component of the combined output of the two machines.

The induction machines were adjusted by means of rotor resistances to have the same slip at equal loads, and the two sets then worked perfectly well in parallel, automatically supplying load to either system as occasion demanded.

SYNCHRONOUS FREQUENCY CHANGERS.

If a synchronous generator is running on no load, its generated E.M.F. is in phase with the terminal E.M.F., but when loaded, these two electromotive forces may no longer be in

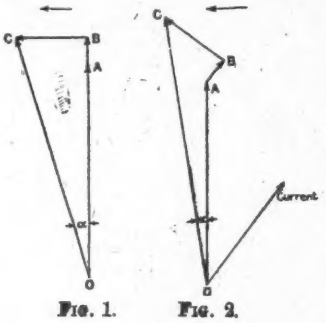


FIG. 1.

FIG. 2.

phase, due to the resistance and inductive drop in the windings. This displacement is shown vectorially in fig. 1 for a load having a power factor of 100 per cent:—

- O A is the terminal E.M.F., and as the load has a power factor of 100 per cent., the current is also in phase with O A.
- A B is the resistance drop in the windings (in phase with the current).
- B C is the inductive E.M.F. (leading 90° with respect to the current).
- O C then gives the phase direction of the generated E.M.F., leading with respect to O A by the angle α.

Fig. 2 shows a similar diagram for a load having a power factor of 80 per cent. lagging.

Similarly in the case of a loaded synchronous motor, the back E.M.F. will lag with respect to the terminal E.M.F. by an angle which we will call β. We see, therefore, that when the frequency changer is loaded, its generator terminal E.M.F. will lag behind its no-load position by an angle of $\alpha + (\beta - \beta_1) f_G / f_M$, where β_1 is the no-load value of β, and f_G and f_M are the respective frequencies of the generator and motor.

In figs. 1 and 2 the value of A B is small compared with O A, and has therefore very little influence on the angle α. B C is approximately proportional to the armature current, and therefore where α is small it is approximately proportional to the output of the machine, if the voltage remains constant.

In the case of a frequency changer converting from 25 to 50 periods, assuming that at full load $\alpha = 20°$ and $\beta = 25°$, if one set is operating at full load and a similar set has to be paralleled with it, the terminal E.M.F. of the incoming machine will be 65 deg. ahead of that of the loaded machine when the generators should be synchronised, and when this is done the sets will divide the load equally.

If the 50-period machines are synchronised before the 25-period machines, the latter will be 34 deg. out of phase when they should be synchronised.

The paralleling of machines when out of phase causes a heavy momentary rush of current and severe mechanical stresses in the stator windings and other parts of the machines, the value of these stresses increasing with the amount by which the voltages are out of phase. If two similar machines are paralleled with their voltages 180 deg. out of phase, the rush of current and mechanical shock will be the same as if each machine had been short-circuited across its terminals.

It is, of course, desirable to keep these stresses as low as possible, and it is therefore an advantage to synchronise the high-frequency machines before those of the lower frequency. A still more satisfactory arrangement is to build the frequency changers with either the motor or the generator stators rotatable through a small angle, either by means of a hand-wheel (similar to the brush-rocking gear of a continuous-current generator), or by a small motor suitably geared to the stator. The stator of the incoming machine can then be rocked round until the generator voltages are in phase, and then rocked in the opposite direction until the set takes the desired load.

If two exactly similar frequency changers are operating in parallel, the total load will be divided equally between them, and any change in the excitation of one generator will only alter the power factor at which each generator is operating, the kilowatt output of each machine remaining practically the same as before.

In order to make one generator take more load than the other, it is necessary to make the generated E.M.F. of the former lead with respect to the E.M.F. of the latter, and this is accomplished by turning the stator of the former generator through a small angle in a direction against the rotation, by means of the rocking gear already referred to. A division of the load proportional to the normal output of the different sets generally gives the highest overall efficiency.

When designing frequency changers which have to operate in parallel, care should be taken that all the sets have as nearly as possible the same phase displacement between the motor and generator terminal electromotive forces at full load, otherwise the load distribution between the different sets will vary with different total loads.

It is also necessary that frequency changers which have to operate in parallel should be so built that when the motor voltages are in phase the generator voltages are also in phase. This is easily achieved if either the motor or the generator stator be made rotatable. If fixed stators are adopted the sets can be made exact mechanical duplicates, but to do this involves considerable difficulties. It is therefore advisable to make the sets approximately similar and to provide some means for final adjustment.

In order to ascertain if the generator voltages of two frequency changers are in phase when the motor voltages are in phase, a simple method is to run the motors in parallel, and connect terminal A of one generator to the corresponding terminal A_1 of the other generator. Both generators are then excited to give exactly equal voltages, and the voltage measured between terminals B and B_1, or C and C_1, will indicate the amount by which the generators are out of phase. These voltages can be plotted graphically to obtain the angle through which one generator stator should be rotated to bring the voltage exactly into phase.

An alternative method is to run the two sets with both the motors and generators in parallel, an ammeter being connected in one phase of the generators. Both generators are then excited with approximately normal field current, the excitation of one being then adjusted so that the alternating current flowing between the two generators is a minimum. If the generated voltages are exactly in phase, this minimum will be zero.

The starting of synchronous frequency changers can be effected either by means of a mechanically-coupled starting motor or by making the synchronous motor (or if desired the generator) self-starting and self-synchronising.

If a separate starting motor is adopted it is usually of the induction type, and may have either a squirrel-cage or a slip-ring rotor, the latter being desirable for large units owing to the smaller momentary starting current required. The starting motor is usually built with one pair of poles less than the synchronous motor, and the rotor resistance is adjusted so that the set runs slightly above synchronous speed when

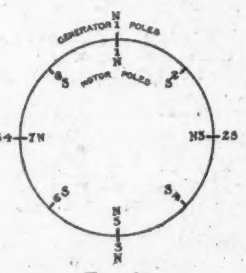


FIG. 3.

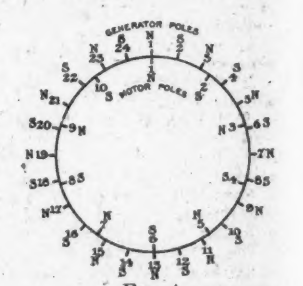


FIG. 4.

the synchronous motor is excited to give normal voltage; the speed is finally adjusted to the correct value by exciting the generator.

If the separate starting motor be dispensed with, and the synchronous motor be made self-starting, the starting current will be increased, but as the machine is self-synchronising this operation is considerably simplified. During the starting period the synchronous motor operates as an induction motor, the field system being usually fitted with a number of copper or brass bars embedded in the pole faces, the bars being short-circuited at each end by metal rings, forming a complete squirrel cage. If solid steel poles are used, this squirrel cage may be dispensed with, the currents induced in the pole faces giving sufficient torque to run the machine up to speed.

Starting is effected by means of an auto-transformer, a voltage of 30 to 50 per cent. of the normal being usually sufficient to give satisfactory starting; the initial line current at starting is about 75 to 150 per cent. of full-load current. The slip-rings of the motor should be short-circuited through a resistance during the starting period, in order to prevent a high voltage being induced in the field coils. When full speed is reached, the field is excited and the machine pulls

into step, the starting switch being then thrown over to the full-voltage position.

When the motors of two identical synchronous frequency changers are running in parallel, the generator voltages will not necessarily be in synchronism, even assuming both sets to be running light.

We will consider the case of two identical frequency changers A and B converting from 50 to 25 periods, the motors having 8 poles and the generators 4 poles. A is running on no load, and it is required to connect B in parallel with A on both the 50-period and 25-period ends.

Fig. 3 shows diagrammatically the positions of the poles on the motor and generator, the radial lines inside the circle representing the centres of the motor poles and the radial lines outside the circle representing the centres of the generator poles.

When the two motors are in synchronism, the N pole 1 of motor B can occupy four positions with respect to the N pole 1 of motor A, viz., positions 1, 3, 5, and 7, but in only two of these positions, 1 and 5, will a N pole of generator B occupy the same relative position as a N pole of generator A. That is to say, with the motor pole 1 in positions 1 and 5, the generator voltages will be in phase, but with positions 3 and 7 the generator voltages will be 180 deg. out of phase. It is therefore seen that with the ratio of frequency conversion under consideration (2 : 1) the probability of obtaining synchronism between the generators when the motors are in phase is 1 to 2.

If it is found that the generator voltages are 180 deg. out of phase when the motors are in synchronism, this can be corrected by reversing the excitation of one generator. If the excitation of one motor be reversed, it will be impossible to synchronise the generators, as their voltages will be 90 deg. or 270 deg. out of phase.

If the 25-period machines are synchronised first, it will be seen that the 50-period machine voltages must be in phase every time.

If we consider the case of some other ratio of frequency transformation, say, 25 to 60 periods, the probability of obtaining correct synchronism of both motors and generators is considerably reduced. With this case the minimum numbers of poles on the motor and generator are 10 and 24, and fig. 4 shows the relative position of the centre lines of the poles of the two machines. When the motors are in phase, pole 1 of motor B can occupy positions 1, 3, 5, 7, or 9 with respect to pole 1 of motor A, but only in the case of position 1 will the generator voltages be in phase. We thus obtain one chance in five of obtaining correct synchronism of the generators.

If the 60-period machines be paralleled first, the chance of obtaining correct synchronism is 1 in 12, which may be increased to 1 in 6 if the 25-period machines are fitted with a field-reversing switch.

It will be found that the chance of obtaining correct synchronism is always greater if the low-frequency machines are synchronised before the high-frequency machines, but, as already pointed out, when a set has to be paralleled with one already on load it is an advantage to synchronise the high-frequency machines first, in order to reduce the angle by which the loaded and unloaded machines are out of phase, so reducing the rush of current at the moment of switching in.

In order to obtain correct synchronism of both motors and generators, one of two methods may be adopted :—

(1) Where the motors and generators are synchronised simultaneously.

(2) Where the motors and generators are synchronised separately.

(1) This method is usually only possible when a separate starting motor is used, because a self-starting synchronous motor will usually pull into step without field excitation, and therefore there is no control over the instant at which it will pull into synchronism.

The most satisfactory arrangement is to have a synchroscope fitted with two pointers, one controlled by the high-frequency and the other by the low-frequency machine. As the machines approach synchronism, the two pointers will rotate at different speeds proportional to the respective slips of the incoming machines controlling them, and the motors should be paralleled when the two pointers simultaneously indicate synchronism.

(2) The motor is first paralleled and the synchroscope connected to the generator; the pointer of the synchroscope will, of course, remain stationary at a position on the dial indicating the phase difference between the bus-bar and the generator voltages. The motor excitation is then reversed, so causing the motor to "slip a pole," when the synchroscope pointer immediately takes up a new position. This operation of reversing the motor field current is repeated until the synchroscope indicates synchronism, when the generator can be switched on to the bus-bars.

If the motor is of the self-starting type, it is advisable to perform this operation of pole-slipping when the motor is running at the reduced starting voltage, as this causes a smaller kick in the line current, and less shock to the motor.

It is important to note that when synchronising the generators in the way just described, the position taken up by the synchroscope pointer will vary with the output of the loaded machine, due to the angular displacement (due to the load) between the motor and generator bus-bar voltages as previously explained. This can be taken care of by fitting the synchroscope with a zero mark, which can be moved over a scale graduated in kilowatts output of the running machine. Before synchronising the incoming machine, the zero mark is moved to the mark on the scale corresponding to the output of the loaded machine, and when the pointer is opposite the zero mark the incoming machine is in the correct phase for paralleling.

In the case of a frequency changer, where neither machine has a rotatable stator, if it is impossible to synchronise the generator correctly, due to faulty machining, &c., the amount by which the voltages are out of phase may be reduced by changing the connections between the stator terminals and the bus-bars.

Considering the case of a 10-pole three-phase motor driving a 24-pole three-phase generator, with the maximum possible error in machining or winding, it is possible to obtain an out-of-phase angle between the generator and bus-bar voltages which will not be greater than 6 deg.

Comparison between Induction and Synchronous Sets.

From the point of view of cost, efficiency, overload capacity, reliability, maintenance, and floor space, both types are practically on an equality (assuming the same synchronous speed with each type). The type to be adopted must, therefore, be determined by the other characteristics of the machines. The difficulty and troubles experienced in connection with the operation of synchronous frequency changers are not as real in practice as one would at first expect. If either the motors or the generators are fitted with rotatable stators, the synchronising and load distribution is as simple, or even simpler, than with induction frequency changers. If the machines have non-rotatable stators, the difficulty of synchronising depends to a great extent on the ratio of frequency conversion.

In any case, the operation of "slipping poles" by reversing the motor excitation is easily carried out, and will quickly bring the generators into the correct phase relation for paralleling.

Taking all the points into consideration, the advantages of the synchronous frequency changer are sufficient to justify its adoption in the majority of cases.

Mr. Partridge, in opening the discussion, said the subject was of great importance in connection with the linking-up proposals. He was sorry the author had not referred to phase changers, and went on to suggest the use of automatic regulating transformers instead of rotating the stators. All his company's motor-generators were now switched in through water resistances, and he thought it would be dangerous to switch-in as suggested by the author. It was not easy to move a large stator, but it might be possible to use some form of magnetic clutch between the two sets. He could not tell whether the author really advocated induction or synchronous frequency changers; personally, he thought the induction type would be simpler to work, and it was a most important feature. There was less danger of the induction type falling out of step, and it was mechanically stronger. For the last six years he had been using a 1,500-kw. machine, running at 365 r.p.m., consisting of a three-phase induction motor with 8 poles coupled to a single-phase 28-pole synchronous motor; damper windings were provided, and the overall efficiency was 86 per cent.; the machine had been satisfactory, and fulfilled all its guarantees. Either side was used to generate current, and it was synchronised by running up on the induction motor; normally it supplied single-phase current; a voltage regulator was fitted, and kept all the single-phase voltage steady.

Mr. J. S. Highfield said it was surprising that frequency had never been standardised; in quite a small area he knew of half a dozen different frequencies. The problem was not so simple, for, as a rule, it was desirable that the link between two undertakings should allow reciprocal supplies to be given, so that a station could be shut down if desired. He thought that linking-up was a temporary expedient, but a very important one, and doubted whether the induction machine would be satisfactory, as probably two synchronous sets would be required. It was questionable whether it would be possible to work a number of frequency changers at different stations, all tied together, and the probable solution was to do away with the odd frequencies.

The Author, in his reply, referred to the design of phase changers, pointing out that some rotating machine was essential in the apparatus. Stators which could be rotated were quite satisfactory in frequency changers, and in some cases a small motor was installed to turn them. He believed that a machine had been built in which the stator was arranged to rotate continuously in case the load exceeded the safe limit. He thought there was no need for an electromagnetic coupling. The frequency changer must be big enough to take care of rapid variations of load without losing step. The solution of all difficulties in paralleling was to use a rotatable stator; the difficult thing to decide was how big a frequency changer should be.

Prices Advanced.—Owing to the continually increasing cost of raw materials, the Herbert Frood Co., Ltd., of Chapel-en-le-Frith, has advanced the prices of Ferodo fabrics 15 per cent.

IMPROVED METHODS OF POWER MEASUREMENT.

[Communicated.]

(*Concluded from page* 192.)

Apart from the more important consumers thus provided for, there still remains the medium and small consumer, who may possibly require both lighting and power; the consumer situated in remote districts; and the consumer who may suddenly wish to increase his demand considerably for a short period. To these classes the schemes already described do not apply very satisfactorily.

What is required is a meter permitting the supply of power up to a certain predetermined amount without registration, and for demands or peaks above this amount registration of the excess units. Fig. 8 shows a simple load curve. The horizontal line A B shows the maximum rate at which energy may be consumed, and which in this case is 1,000 watts. Whilst the demand does not exceed this line, registration must not occur, whilst when "peaks" such as X Y Z occur, the units, as shown by the shaded area, must be recorded by the meter. With such an instrument it is at once seen that:—

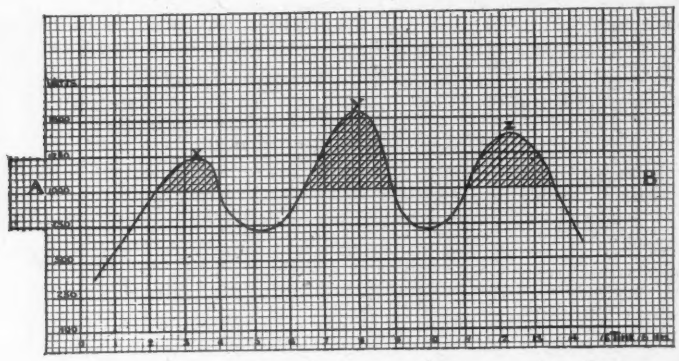


Fig. 8.—Differential Meter—Load Curve.

1. Supply is unrestricted.
2. Peak periods are penalised, and therefore discouraged, a heavy charge being made for units registered
3. A fixed revenue per month, quarter, &c., as the case may be, is assured, and the excess units need only be read and charged, say, twice a year, making this scheme particularly suitable for remote consumers.

As the name "differential" implies, the registration is the difference between the maximum allowable load and that demanded in excess.

Several ingenious devices have been evolved, usually costly in construction, and not entirely satisfactory in principle; these are known under various names, such as: Differential meter; subtraction meter; excess meter; peak meter, &c.

Obviously, a retarding torque must be applied to the meter movement equal to the torque developed by the meter at the maximum allowable load without registration. This has been attained in a variety of ways, as follows:—

1. *Shaded Pole Magnet.*—A small electromagnet provided with a shaded pole and excited from the voltage, acts on the disk so as to oppose rotation in the normal direction. A ratchet and pawl prevent backward rotation, and until the torque of the meter can overcome that of the shaded-pole magnet, rotation does not occur. This suffers from the defect that the retarding torque of the shaded-pole magnet varies as the square of the voltage, and a 10 per cent. error is possible with only a 5 per cent. variation of voltage.

2. *Demagnetisation of Driving Fluxes.*—A small transformer is connected with the primary winding across the voltage. The secondary winding is of low voltage and greater current, and this current is passed through an additional coil on the ordinary series winding, so arranged as to oppose the magnetising effort of the series coil in the meter. When the load is sufficiently great the ordinary series winding overcomes the demagnetising winding, and the meter begins to register. Assuming the voltage to be constant, the demagnetising effect is constant, and by suitably arranging the number of turns, can be made such as to permit of a certain load before registration occurs. However, as the voltage is never constant, and as the variation may be as great as 5 per cent., the error introduced will be in proportion to the variation of voltage. This principle is applied in various ways, but is always subject to the above defect.

3. *Differential Gears.*—Two dials are utilised, one being engaged with the meter and the other with a constant-speed device, operated from either a mechanical hand-wound clock mechanism or a small Ferraris motor, the latter avoiding the periodical visits necessary in the case of hand-wound instruments.

The two dials are connected together by a differential gearing, and when the speed of the gear wheels driven from the meter movement exceeds the speed of those driven by the constant-speed device, registration of the excess units occurs.

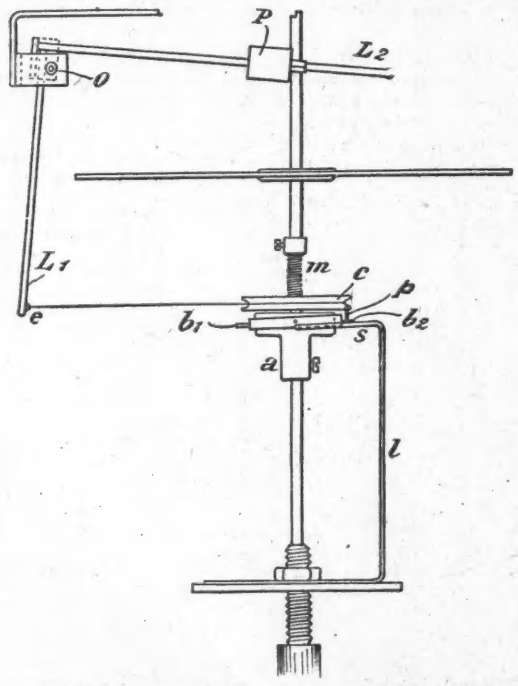


Fig. 9.—Diagram of Westinghouse Differential Meter Gear, as Applied to Induction Watt-hour Meter.

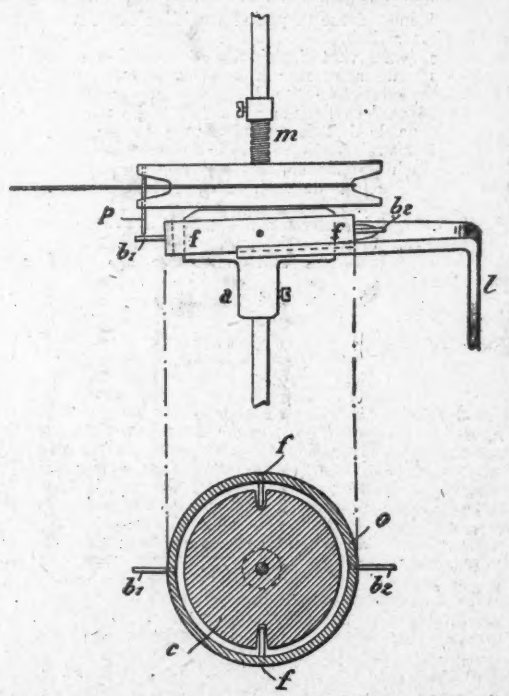


Fig. 10.—Differential Gear Applied to Watt-hour Meter.

Suitable means are adopted to prevent negative registration when the speed of the meter dial train is less than that of the constant-speed dial train. There are many disadvantages to this method, for it necessitates delicate and expensive mechanism, periodical visits in the case of hand-wound instruments, and in the case of the Ferraris motor the constant-speed dial must be driven by some kind of clock escapement to ensure this constant speed, for otherwise it will vary as the frequency.

The foregoing are probably the most satisfactorily deve-

loped instruments up to now, but they all fail in that they require special design. Further, the elaborate mechanism makes them expensive, while with only a limited range of adjustment, once calibrated, very little alteration, if any at all, is possible.

The British Westinghouse differential device not only has the advantage of being absolutely independent of the conditions of supply (voltage, frequency, wave form, &c.), but has also that of great simplicity, permitting it to be fitted to standard designs; it is, therefore, a decided advance on its predecessors.

The retarding torque is obtained by means of a weight at a fixed radius from the centre of the spindle. The meter movement operates against this torque continuously, and when sufficient current is passing, registration occurs. Figs. 9 and 10 are diagrammatic sketches of the gear as applied to an induction watt-hour meter. The weight P is carried on a bell-crank lever L_2 O L_1, pivoted at O.

A grooved pulley *c* is loose on the shaft, being held in position by means of the spring *m*, pressing it against the disk *a*, which is rigidly attached to the shaft. A silken cord connects the lower end L_1 of the bell-crank to the grooved pulley C. The fixed disk *a* carries an oscillating collar *ff* (fig. 10), pivoted at *ff*, this collar in its turn carrying pins b_1, b_2. These pins engage with the vertical pin *p* on the grooved pulley.

When the torque of the meter is sufficiently big to overcome that due to the weight P, the movement rotates, winding up this weight by means of the grooved pulley C. As rotation continues, one side of the oscillating collar rides on the fixed spring *s l*. This spring *s l* is so arranged as to tilt gradually the oscillating collar until finally the engaging pin *p* on the pulley is released from the pin b_1 on the collar. The weight P is then released, and in falling turns the grooved pulley a half revolution in the opposite direction to

Fig. 11.—Differential Mechanism applied to Westinghouse Type N Single-phase Meter.

rotation, when re-engagement between the pin *p* and the pin b_2 occurs, for pin b_2 is then at its highest position. Rotation continuing, the side of the collar with pin b_1 gradually rides upon spring *s l* until the grooved pulley is released again, the weight falls, and pins b_1 and *p* re-engage.

The weight is so arranged that when it has fallen to its lowest position it is still exerting the same retarding torque as when in its top position. This is obtained by suitably proportioning the arms of the bell-crank lever to overcome the slight angular error of the falling weight. Further, for the short time the weight P is falling, the meter would tend to accelerate, but this time is extremely short, and is off-set by the shock in a negative direction when re-engagement occurs.

Without further discussion of possible errors, it is enough to say that the instrument may be calibrated extremely accurately.

Fig. 11 shows a view of the mechanism as applied to a type N single-phase meter, and the extreme simplicity of construction is at once seen. This simplicity has the additional advantage that very little trouble is likely to be experienced, while if trouble has developed it can easily be rectified.

Further, by altering the position of the weight P, the retarding torque is altered and a very wide range is permissible.

A scale whereby the distance from centre O is equivalent to a maximum permissible load is easily obtainable, and alterations can be carried out on site with perfectly accurate results. For example, if the distance of the weight from centre O is two centimetres, and the maximum permissible load without registration is 1,000 watts (10 amp. at 100 volts), moving the weight to a distance of four cm. would increase the limit to 2,000 watts.

The weight is so arranged as to permit of easy and quick readjustment, and, as the arm O L_2 is approximately five cm. long, a very wide range is possible.

Very little additional friction is introduced, and in any case it is amply compensated for. This device practically fulfils all the conditions specified previously, and enumerating the various advantages we have:—

1. No interference with supply.
2. Peak periods penalised.
3. Frequent periodic visits unnecessary, readings every six months being amply suitable for remote customers.
4. Definite revenue each month based on maximum allowable load.
5. Retarding torque absolutely constant, independent of voltage, frequency, wave form, &c.
6. Wide range of adjustment possible, easily and quickly carried out on site if necessary.
7. No elaborate mechanism, therefore friction a minimum; low cost makes it suitable for the medium and small consumer.
8. Accurate calibration.
9. No auxiliary shunt circuits, contacts, &c.

This device, as developed by the British Westinghouse Co., is a very satisfactory appliance, and will enable supply companies to deal suitably with the medium and small consumer.

THE GREAT NEED OF PROMOTING RESEARCH IN AMERICA.

In the New Year issue of the *Electrical World*, Dr. W. R. Whitney, director of the Research Laboratory, General Electric Co., had a special article on this subject. In a rapid review of the history of the American nation, he indicated how the resources of the country had been successively drawn upon with feverish haste and little thought for the future, and proceeded to rebuke his fellow-countrymen for their devotion to mere commercialism without regard to the higher aims of civilisation.

The special significance of his remarks lies in the fact that he is at the head of the great laboratory from which some of the most striking and important discoveries have emanated during recent years in connection with industrial research; yet he lays stress on the necessity of research in pure science, which has hitherto received but little attention in the United States. We reproduce the bulk of the article below:—

Coincident with our history, other countries, somewhat differing from our own, have been increasing the world's store of knowledge by a certain system. It is by utilising this store that we have made most of our advances. From it we have made our engines, healed our wounds and cured our sick, talked through wires, and heard through infinite space. We inventors and engineers, using, generally, the scientific products of foreign lands, have turned knowledge into utility. But we have taken no time to contribute to the world's needed supply of new facts. We owe a debt we hope our descendants will pay. We might as well defy them to pay it.

Compared with other countries, we have been exceedingly short-sighted. We are much more active as users than as producers of knowledge. We make no provision for repairing the rapid exhaustion of our soils, replacing our disappearing coal and oil, or providing the new knowledge on which future life or happiness must be based. Inventors and engineers are being rapidly grown, but searchers to unearth the knowledge on which engineering is based are not being produced. Other countries have provided for the education, support, and encouragement of men who practically devoted their lives to pure or scientific research. Their investigations seemed more or less academic. These were careful physical analyses of natural phenomena which, at the time, had no visible utilitarian value. It is not surprising to find that most of the foundations of engineering have come to us through professors of science in European universities or institutions.

As we review the history of scores of such cases, it is evident that most foreign universities have held teaching to be secondary to research, and have, for several decades, at least, employed and given great facilities to men who made experiments their life work and taught science for the purpose of preparing similar investigators. It is we Americans who have prostituted teaching for the use of the industries.

In a volume on German culture, edited by a group of English writers, there are comparative lists of great contributors to engineering science. There are listed 12 leaders in chemistry and 12 in physics from England, France, Germany, and the rest of the world, making 96 in all. They were the producers of new science in the nineteenth century. Of these 96, only 5 were from the United States; 48 mathematicians are also compared, and no American is among them.

Another and different criterion occurs in the recipients of the Nobel Prizes. These are annually awarded, without regard to country, to the individual who is most deserving in the particular fields of physics, chemistry, physiology or medicine, literature,

and peace. Here, again, we do not shine very brightly. In physiology or medicine, among the 13 awards down to 1914, America had received one. Also in physics, the United States had received one out of 13, and in chemistry none. That is, in new and constructive scientific work of this kind during these recent years, America had been recognised only twice out of 39 chances.

While we may be doing our share in the applications of science, we have failed in laying foundations. Until we can learn to do still better, let us follow the example of the German Universities or of the British Institutions. There the teaching of science is not confined to the preparation of men to earn a living as engineers. In practically every one of scores of Universities, particularly in Germany, there are professors whose main object seems to be to advance knowledge, to discover new facts, and to teach by precept the acquirement, instead of the storage of information. They work with their own hands. The very great value of these professors is seldom realised, and so I want to call to mind a few of them. The point I wish to make is that apparently most of our advances may be traced back to one of these professors, who, trained to be an observer, matured in a laboratory supported by the State, has had time and facilities to follow the lead of some natural observation.

Consider electric lighting, for example. The earliest impetus was given to it by experiments using the cells of Grove and Bunsen. They were famous for their research and teaching as well. One was a professor in England, the other in Germany. The publications on these batteries at the time show the men to have made careful and interested studies of novel phenomena. Of course, they had no thought of electric lights, and even when these were produced by battery currents, much as in pocket lamps to-day, there was no commercial development until the current-generating machines were produced. But even with the cells of Grove, Sir Humphry Davy produced the first electric arc between carbon electrodes. Davy was for many years the chief chemist and lecturer of the Royal Institution. If we go back of Grove or Bunsen, we come to the professors of Boulogna and Pavia, who made the first researches on current generation. Galvani investigated the frog's legs and Volta the metal pile. They published their observations. Fundamental observations and the necessary experiments are always more certain to be performed by such trained observers than by others. Faraday, the life-long investigator of the Royal Institution, had disclosed the principles of the generation of electric current by using permanent magnets, and further research then became rapid. Apparently Prof. Wheatstone made the first machine for producing current by mechanical means without permanent magnets, though Siemens presented his paper to the Royal Society first, and both were read before the Society the same evening. In either case the product came from the kind of mind and the type of study which I am showing contributes to our knowledge. The contributions of pure research are seldom in response to recognised needs, but the needs themselves are developed or disclosed through the research.

The more recent history of lighting is filled with the studies of engineers and students, and greatest of these is Edison, but even here one cannot help noting the radical or unexpected steps whose foundations are laid in the professor's laboratory. An entirely new type of electric illuminant was disclosed by Prof. Nernst by his studies of oxide conduction. Dr. Welsbach, in rare oxide investigations, not only found the gas mantle, but produced the osmium incandescent lamp as well. Von Bolton, student of Ostwald, and highly trained in experiments, worked out tantalum and produced a new lamp, and even the recent tungsten gas lamps depend on the purely scientific researches of the able English professors—Rayleigh and Ramsay—for the argon used in them.

Readers of *Popular Mechanics* some time ago selected by vote the seven wonders of the modern world. The highest votes were received by wireless, the telephone, aeroplane, radium, antiseptics, antitoxins, spectrum analysis, and X-rays. How were these originated? All of them were produced by the identical formula. In the first place, they were not the result of a direct attempt to accomplish what was really attained. The end was not visible when the foundations were laid. The real work was done by thoroughly well-trained observers—not by laymen. They were professors in every case. They followed up a lead opened by an observation which was too insignificant to attract the attention of less trained men.

It would be impracticable to give the histories of these so-called wonders. Anyone who reads may learn how Prof. Helmholtz, an expert German investigator, was the instigator of the work of Hertz, which in turn was based on the principle of Maxwell that variation in electric displacement is electric current. This, Maxwell had derived from work on Faraday's researches. And thus, in the foundations of the single wonder of wireless, we find the co-operating efforts of at least four experimenting professors of science. They were all working for the public, and supported by a university or public institution.

Radium and X-rays are of such recent disclosure, that it is hardly necessary to recall that the work was done by English, German, and French professors.

One might well conclude from the history of the British Royal Institution alone that pure research was a good governmental investment if the environment was capable of developing such products as Davy, Faraday, Tyndall, and Rayleigh. Surely we may hope to awaken ourselves to the importance of constructive action for the advancement of science. If we count only on such private bequests as have already helped so much in studies of disease, we are evidently not awake. Federal appropriations to assist American colleges in research seem a fair way to discover and produce good men, and to economically supply them with apparatus and atmosphere.

NEW PATENTS APPLIED FOR, 1917.

(NOT YET PUBLISHED).

Compiled expressly for this journal by MESSRS. W. P. THOMPSON & Co., Electrical Patent Agents, 285, High Holborn, London, W.C., and at Liverpool and Bradford.

1,796. "Electric fuses." J. F. AVILA, SIMPLEX CONDUITS, LTD., & L. M. WATERHOUSE. February 5th.

1,802. "Manufacture of carbons for electric arc lamps." H. B. GRYLLS AND W. HEAPS. February 5th.

1,851. "Electromagnetic switches." BRITISH THOMSON-HOUSTON CO. (General Electric Co., U.S.A.). February 6th.

1,867. "Electro magnets." CUTLER-HAMMER MANUFACTURING CO. & IGRANIC ELECTRIC CO. February 6th.

1,880. "Spark plugs." C. F. ARNOLD. February 7th. (U.S.A., February 7th, 1916.)

1,921. "Automatic trolley alarm or signal for electric tramcars." HORSTMANN GEAR CO. & R. DODD. February 8th.

1,930. "Art of metering electricity." E. O. SCHWEITZER. February 8th.

1,948. "Electrical heating apparatus." H. DE STEFANO. February 8th.

1,953. "Electromagnetic switches." BRITISH THOMSON-HOUSTON CO. AND GENERAL ELECTRIC CO. February 8th.

1,962. "Electric ovens." J. BRADLEY. February 8th.

1,971. "Trolley-wire locator." F. J. DAVIS. February 8th.

1,978. "A fault-finder for testing cylinders, sparking plugs, and magnetos of internal-combustion engines ignited by electricity." A. VEITCH. February 9th.

1,985. "Electric lamp locks." J. H. COLLIE. February 9th.

2,011. "Safety spark gaps for magneto-electric machines." BRITISH THOMSON-HOUSTON CO. & A. P. YOUNG. February 9th.

2,022. "Ignition devices for internal-combustion engines." J. J. MURRAY. February 9th.

2,026. "Trolley heads for electric traction." W. PICKERSGILL & J. H. PITT. February 10th.

2,040. "Polyphase electromagnetic brakes, clutches, &c." F. H. KERSHAW. February 10th.

PUBLISHED SPECIFICATIONS.

1915.

16,898. ALTERNATING-CURRENT MOTOR STARTERS. Electric Control, Ltd., and O. Ellefsen. December 1st.

1916.

The numbers in brackets are those under which the specification will be printed and abridged, and all subsequent proceedings will be taken.

665. MACHINES FOR MAKING ELECTRIC CABLES OR THE LIKE. Macintosh Cable Co. & P. W. Sankey. January 15th, 1916. (Cognate application, 9,736/16.) [103,316.]

681. ALTERNATING-CURRENT DYNAMO-ELECTRIC MACHINES, INDUCTION REGULATORS, AND OTHER ELECTRICAL APPARATUS. British Thomson-Houston Co. and F. P. Whitaker. January 15th, 1916. [103,317.]

1,076. VIBRATING DIAPHRAGMS FOR TELEPHONES, TRANSMITTERS, GRAMOPHONES, AND THE LIKE. T. Chalmers. January 24th, 1916. [103,335.]

1,189. TELEPHONIC RECEIVING APPARATUS FOR AVIATORS OR OTHERS WORKING UNDER SIMILAR CONDITIONS. Western Electric Co. & G. H. Nash. January 25th, 1916. [103,341.]

1,255. REGULATION OF ELECTRIC INDUCTION MOTORS. British Thomson-Houston Co. & N. Shuttleworth. January 26th, 1916. (Cognate application, 2,261/16.) [103,344.]

1,282. ARRANGEMENTS FOR TRANSMITTING IMPULSES, PARTICULARLY APPLICABLE IN TELEPHONE SYSTEMS. Relay Automatic Telephone Co. & L. C. Bygrave. January 26th, 1916. [103,345.]

1,384. INCANDESCENT GAS-FILLED ELECTRIC LAMPS. A. J. West. January 28th, 1916. [103,351.]

1,481. SWITCHES FOR USE WITH ELECTRIC GENERATORS. E. Girardeau. January 29th, 1915. [100,042.]

3,535. ELECTRIC RELAYS. National Safety Appliance Co. May 5th, 1915. [103,389.]

4,334. ELECTRIC LOCOMOTIVES. British Thomson-Houston Co. (General Electric Co., U.S.A.). March 23rd, 1916. [103,387.]

6,326. ELECTRICAL APPARATUS FOR INDICATING THE DEPTH OF LIQUIDS IN TANKS OR OTHER VESSELS. J. Plummer & G. B. Burrows. May 3rd, 1916. [103,403.]

7,014. ELECTRIC FURNACES. M. M. Kohn. May 17th, 1916. [103,062.]

7,186. INSULATION OF ELECTRICAL MACHINERY AND OTHER APPARATUS. C. H. Klyne & C. J. Baker. May 19th, 1916. [103,413.]

7,518. ELECTRIC SHIP PROPULSION SYSTEMS. R. V. Morse. May 26th, 1916. [103,065.]

7,607. RELAY SELECTORS, ESPECIALLY SUITABLE FOR USE IN AUTOMATIC AND SEMI-AUTOMATIC TELEPHONE SYSTEMS. Relay Automatic Telephone Co. & H. J. Herink. December 11th, 1915. [102,330.] (Divided application on 17,386/15.)

8,216. SPARKING PLUGS FOR INTERNAL-COMBUSTION ENGINES. F. A. L. Johnson. June 10th, 1916. [103,420.]

8,858. METHOD OF AND MEANS FOR VARYING THE RESISTANCE OF AN ELECTRIC CIRCUIT. Igranic Electric Co. (Cutler-Hammer Manufacturing Co., U.S.A.). June 23rd, 1916. [103,254.]

9,349. AUTOMATIC SWITCHING DEVICES FOR WIRELESS TELEPHONE SYSTEMS. L. de Forest. July 7th, 1915. [100,841.]

10,070. ELECTRIC CABLE JUNCTION OR TERMINAL BOXES OR APPARATUS. C. Vernier and British Insulated & Helsby Cables, Ltd. July 18th, 1916. [103,435.]

10,116. ELECTRIC MOTOR CONTROLLERS. Igranic Electric Co. (Cutler-Hammer Manufacturing Co., U.S.A.). July 18th, 1916. [103,436.]

10,122. ELECTRIC VACUUM DEVICES WITH INCANDESCENT CATHODES. L. de Forest. July 22nd, 1915. [100,959.]

10,611. AUTOMATIC TELEPHONE CALL DISTRIBUTING SYSTEMS. Western Electric Co. December 19th, 1914. [101,033.] (Divided application on 17,481/15.)

11,327. ALTERNATING-CURRENT DYNAMO-ELECTRIC MACHINES OF THE COMPENSATED COMMUTATOR TYPE. British Westinghouse Electric & Manufacturing Co. (Westinghouse Electric & Manufacturing Co., U.S.A.). August 10th, 1916. [103,265.]

10,640. CONTROLLERS FOR ELECTRIC MOTOR CIRCUITS. Igranic Electric Co. (Cutler-Hammer Manufacturing Co., U.S.A.). July 27th, 1916. [103,441.]

11,691. MAGNETO-IGNITION SYSTEMS. Soc. de Paris et du Rhone. December 6th 1915. [102,606.]

11,736. CONSTRUCTION OF POCKET OR PORTABLE ELECTRIC LAMP. W. King (I. Chkliar & B. Theodor). August 18th, 1916. [103,268.]

13,727. ELECTRIC HEATING AND COOKING APPARATUS. G. Pate & A. K. Wood. September 27th, 1916. [103,279.]

14,946. MAGNETS FOR MAGNETO-ELECTRIC MACHINES. G. F. Cooke. October 20th, 1916. [103,461.]

17,321. ELECTRICAL CONTACTS. British Westinghouse Electric & Manufacturing Co. January 21st, 1916. [103,464.]